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APOLLO MISSION C' SPACECRAFT OPERATIONAL TRAJECTORY ALTERNATE 1, LUNAR ORBITAL MISSION

VOLUME I

MISSION PROFILE FOR A MISSION LAUNCHED DECEMBER 21, 1968

Lunar Mission Analysis Branch

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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PROJECT APOLLO

APOLLO MISSION C' SPACECRAFT OPERATIONAL TRAJECTORY ALTERNATE 1, LUNAR ORBITAL MISSION VOLUME I - MISSION PROFILE FOR A MISSION LAUNCHED DECEMBER 21, 1968

By Lunar Mission Design Section
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Approved: Ronald L. Berry
Ronald L. Berry, Chief
Lunar Mission Analysis Branch

Approved:
John P. Mayer, Chief
Mission Planning and Analysis Division

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1.0 SUMMARY AND INTRODUCTION

The spacecraft operational trajectory for Mission C' - Alternate 1, is composed of four volumes which summarize the spectrum of missions for a 2-month launch period (December 1968 and January 1969). Other than this volume, Volume I, the operational trajectory document consists of the following volumes.

1. Volume II - Trajectory Parameters for a Mission Launched December 21, 1968: Listing of significant trajectory parameters computed at selected time points during each phase of the same typical mission described in this volume. It also contains a tracking acquisition and loss table. (MSC Internal note no. 68-FM-253.)

2. Volume III - Summary of Missions for December 1968 Launch Window: Summarizes missions for specific launch azimuths (72°, 81°, 90°, 99°, 108°) and summarizes selected parameters as a function of launch azimuth (72° through 108°) for each daily window (December 20 through December 27). (MSC Internal note no. 68-FM-254.)

3. Volume IV - Summary of Missions for January 1969 Launch Window: Summarizes missions for specific launch azimuths (72°, 81°, 90°, 99°, 108°) and summarizes selected parameters as a function of launch azimuth (72° through 108°) for each daily window (January 18 through January 24). (MSC Internal note no. 68-FM-255.)

Although this volume of the operational trajectory document presents a mission profile for a December 21, 1968 launch, 72° launch azimuth, first injection opportunity, the profile should be interpreted as being typical of the lunar missions planned during both the December and January windows. Therefore, the guidelines and constraints, the launch

window description (summarized in table I), and tracking ship placement (discussed in section 6.0) apply to the spectrum of missions summarized in Volumes III and IV.

The missions were designed for a daylight launch and reasonable lighting in the Apollo zone. In the initial design "target sites" (some of which are Apollo landing sites) and approach azimuths to these sites were selected for each launch date to provide favorable trajectory characteristics. Lunar orbit inclination, inclination of the free-return trajectory, and propellant reserves were the main parameters considered in this initial design.

Table I shows the target site designation, the selected approach azimuth, and lighting conditions at each site for each launch date. Table II shows the designation and location of the sites. In general, the lighting is not favorable at the target sites for the landmark tracking objectives. Therefore, lunar landmarks are being selected for each launch date in a longitude region of acceptable lighting (approximately 5° elevation with respect to the local horizontal). These landmarks are not yet available.

It is emphasized that the launch vehicle operational trajectory (ref. 2) published by MSFC is the official source for LV data. Data related to the launch and translunar injection is included in this document because it is approximately correct and is informative.

A mission lighting document is being published which summarizes the lighting for the major mission phases for both monthly windows (ref. 1).

The translunar injection tracking ship section of this document was prepared by Mrs. M. B. Vick of the Mission Design Section of the TRW Systems Group.

The entry phase was computed and documented by the Reentry Studies Section of the Landing Analysis Branch, Mission Planning and Analysis Division.

As revisions for this basic profile evolve, this document will necessarily be revised.

2.0 ABBREVIATIONS

A/RIA	Apollo Range Instrumentation Aircraft
c.g.	center of gravity
CM	command module
CSM	command and service modules
DSKY	display keyboard
EMS	entry monitoring system
EPO	earth parking orbit
EOI	earth orbit insertion
g.e.t.	ground elapsed time from lift-off
GNCS	guidance and navigation control subsystem
IGA	inner gimbal angle
IMU	spacecraft inertial measurement unit
ISP	specific impulse
L/D	lift-to-drag ratio
LH2	liquid hydrogen
LM	lunar module
LOI	lunar orbit insertion
LOI(1)	lunar orbit insertion into 60- by 170-n. mi. orbit
LOI(2)	lunar orbit circularization burn - from 60 by 170 to 60 by 60 n. mi.
LPO	lunar parking orbit
LOX	liquid oxygen

LTAB	lunar test article (B)
LV	launch vehicle
MCC	midcourse correction
MGA	middle gimbal angle
MSFC	Marshall Space Flight Center
MSFN	Manned Space Flight Network
NPV	nonpropulsive vent
OGA	outer gimbal angle
PV	propulsive vent
RCS	reaction control system
REFSMMAT	transformation matrix from inertial to stable member (IMU)
SC	spacecraft
SCT	scanning telescope
S-IVB	launch vehicle third stage
SLA	spacecraft LM adapter
SM	service module
SPS	service propulsion subsystem
TB_7	time base seven - initiated at TLI cutoff
TEI	transearth injection
Tig	time of ignition
TLI	translunar injection

3.0 PRIMARY GUIDELINES AND CONSTRAINTS

The design of the mission and the resulting launch windows were based on the following primary guidelines and constraints:

a. Launch will occur between 30 minutes prior to sunrise and 30 minutes after sunset.

b. The launch azimuth spread will be from 72° to 108° unless other constraints, such as daylight launch, restrict the azimuth range.

c. Launches will be planned on consecutive days throughout the available monthly windows.

d. The first TLI injection opportunity will occur on the second earth parking orbit, and the second opportunity on the third orbit.

e. TLI will be targeted for a free-return circumlunar trajectory.

f. All CSM/SPS maneuvers will utilize external ΔV guidance.

g. LOI will be performed in two stages with the first burn, LOI(1), resulting in a 60- by 170-n. mi. ellipse and the second, LOI(2), circularizing the orbit at 60 n. mi. two revolutions later.

h. The lunar orbit geometry will be chosen such that passage over known lunar landmarks will occur with no significant penalty in SC performance.

i. Approximately six unperturbed (no translation maneuvers) lunar orbits will be available for tracking and navigation. A total of ten orbits will be planned - allowing two orbits for post-LOI activities and two orbits for pre-TEI activities.

j. TEI will be targeted to a landing longitude of 165° W.

k. Transearth return inclination will be limited to a maximum of 40°.

l. Entry range will be 1350 n. mi. (relative range).

m. Transearth entry speed will be limited to a maximum of 36 323 fps (inertial). This corresponds to a minimum transearth flight time of approximately 50 hours.

n. The transearth trajectory will be targeted to an entry path angle of -6.26°. (It should be noted that this guideline is incompatible with a recent decision to target nominally to a steeper flight-path angle, i.e., -6.48°. The steeper targeting will be reflected in the first revision of this document.)

4.0 LAUNCH WINDOW DESCRIPTION

Three constraints determined the daily launch windows and translunar injection window as they are currently defined within the December and January launch months.

a. Free-return circumlunar constraint.

b. Acceptable lunar lighting within the Apollo zone.

c. Daylight launch (30 minutes prior to sunrise - 30 minutes after sunset).

The daily launch window for a specified site is determined by the acceptable lighting range at that site coupled with the free-return constraint.

The duration of a daily window is restricted by the daylight launch constraint on certain days in both the December and January windows.

The Pacific injection window for both December and January is dictated by the daylight launch requirement coupled with acceptable lighting within the Apollo zone. Table I shows the opening and the duration of the daily windows for December and January. The times shown are related to the total azimuth spread (72° to 108°) and do not reflect the daylight launch constraint. The duration of the total window for all dates is approximately 4^h35^m.

Figures 1(a) and 1(b) are plots of launch azimuth versus launch time and show how certain daily windows in December and January are restricted by the daylight constraint.

On December 20 [fig. 1(a)] the first acceptable azimuth is approximately 80°, the window duration is about 4^h0^m, and opens at about 6^h53^m e.s.t. The windows for the following dates open at successively later times until on December 27, the first opportunity is about 16^h45^m e.s.t.

On December 25, 26, and 27 the windows are restricted at the end of the azimuth spread. On the 25, the last launch azimuth available is 102° and the duration of the window is 4^h09^m. On December 26 the last azimuth is 89° and the duration is 2^h44^m. On December 27, the last azimuth is 78° and the duration of the window is 1^h15^m.

In the January window, none of the openings are restricted by daylight launch [fig. 1(b)], but the closing of the January 23 and 24 windows are restricted as follows: On January 23, the last launch azimuth available is about 96° and the window duration is 3^h50^m. On January 24, the last launch azimuth available is about 83° and the window duration is 2^h35^m.

In the above description of the launch windows the only constraint discussed in detail was daylight launch. Other considerations may further restrict the windows such as lighting for particular phases, possible earth landing for the free-return circumlunar trajectories, and translunar injection coverage. These considerations are being studied and the results will be published at a later date.

5.0 OPERATIONAL MISSION PROFILE DESCRIPTION

This section summarizes a mission profile for a December 21, 1968 launch date. The burn times, propellants used, and most mission phase times are typical of the lunar orbital missions planned for the December and January launch windows, which are summarized in Volumes III and IV.

The profile is concisely presented in table III. In this section, major events, spacecraft performance characteristics, and significant trajectory parameters are described in detail for each phase.

In the design of the spacecraft operational mission, the LV mission phases were simulated independent of the exact LV operational trajectory. The trajectory data presented here for the LV mission phases were simulated with LV data received from the MSFC in a previous intercenter targeting exercise. No attempt was made to exactly duplicate the LV operational mission, and the information for the LV phases will differ from that in the official trajectory document (ref. 2). The parameters for the LV mission phases should be considered as typical values only.

The data presented in tables IV and V apply to the missions throughout the window. Table IV, the spacecraft weight and engine characteristics, were taken from reference 3. Table V lists the assumed mission-independent expendables. These data and spacecraft weights in table IV were used to determine mission fuel reserves and weight histories.

Tables VI and VII give the mission radar and shadow timelines for all mission phases except launch. The radar acquisition and termination data are presented for both 0° and 5° minimum elevation angles. The tracking information in table VI is presented only for the selected launch azimuth (72°) and the first injection opportunity[a].

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[a]General information for the 72° through 108° launch azimuth range for three earth parking orbits is presented in references 4 and 5. Tracking information for the launch phase 72° through 108° is given in reference 6. These data were derived using now outdated LV trajectories but are still useful as information.

5.1 Earth Launch[a]

The launch time for this mission was determined to provide an optimized injected payload to support two injection opportunities. It is emphasized that the launch time, in particular, differs slightly (a matter of seconds) from the official launch time in the MSFC LV operational trajectory.

To provide a daylight launch and acceptable lighting in the Apollo zone, the mission was designed for a Pacific injection. The launch is summarized as follows:

Date, month, day	December 21, 1968
Time, hr:min:sec, e.s.t.	07:50:59.7
Azimuth, deg	72
Location (Cape Kennedy, Complex 39A)	
Latitude	28°36'30.32"
Longitude	279°23'45.12"

5.2 Earth Parking Orbit[a]

Insertion into EPO occurs at 00:11:19.7 g.e.t. The insertion conditions are:

Insertion location	
Latitude, deg	32.7
Longitude, deg	-54.3
Altitude, n. mi	103.3
Inclination, deg	32.6

The insertion ship positioned at 25° N latitude and 49° W longitude tracks the vehicle for approximately 4 minutes (0° minimum elevation angle) after insertion. A ground track of the EPO phase is given in figure 2(a).

[a]The parameters for this phase are approximate and are presented for information only. The official source for this phase is the MSFC launch vehicle operational trajectory (ref. 2).

The LV maintains local horizontal attitude throughout the EPO phase except for an inertial hold of about 10 seconds immediately following EPO insertion. The total time spent in EPO is 2^h39^m.

5.3 Translunar Injection[a]

The TLI burn occurs over the Pacific ocean during the second revolution in EPO:

TLI burn initiation, hr:min:sec, g.e.t.	2:50:31.2
Latitude, deg	9.6
Longitude, deg	-165.9
TLI cutoff:	
Latitude, deg	21.1
Longitude, deg.	-144.5
Altitude, n. mi.	173.6
Flight-path angle, deg	7.5
Inertial velocity, fps.	35 582
Burn duration, sec.	311.5
S-IVB propellant used, lb	151 000.
Plane change, deg	2.6

TLI is initiated in darkness and the vehicle enters sunlight approximately midway through the TLI burn.

Coverage for the major part of the burn is provided by Hawaii, which acquires shortly after ignition. Additional support of the burn and preignition sequence is supplied by one of the injection ships (table VIII).

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[a]The parameters for this phase are approximate and are presented for information only. The official source for this phase is the MSFC launch vehicle operational trajectory (ref. 2).

5.4 Free-return Circumlunar Trajectory

Free-return touchdown is near the western coast of Africa. A water landing can be insured by applying a corrective maneuver at an acceptable time during either the translunar or transearth coast phases of the circumlunar trajectory. The trajectory is characterized by the following:

Pericynthion	
Time, hr:min:sec, g.e.t.	69:09:29.4
Altitude, n. mi.	60.2
Latitude, selenographic, deg	-9.1
Longitude, selenographic, deg	-174.8
Return vacuum perigee altitude, n. mi.	16.4
Transit time from TLI to earth perigee, hr:min:sec	133:29:35
Earth entry:	
Time, hr:min:sec, g.e.t.	136:25:18.2
Altitude, n. mi.	65.8
Latitude, deg N	20.7
Longitude, deg W.	37.7
Inclination, deg.	28.4
Touchdown:	
Longitude, deg W.	16.7
Latitude, deg N	10.9

5.5 Posttranslunar Injection Events

A summary of the major events from TLI cutoff through LOX blowdown is given in table IX. In determining the separation attitude maneuver (TB_7-plus-900 seconds), the sun was constrained to between 32° and 90° of the LV +X-axis. This provides over-the-shoulder lighting and avoids any CSM shadow on the S-IVB for the station keeping position. The SC event times on board will be referenced to TLI ignition (column 1 of table IX) and the LV event times to TB_7. Therefore, the SC event times will vary with respect to TB_7 as TLI burn time varies. The SC maneuver times referenced to TB_7 in the table assumed a 300-second TLI burn time.

The purpose of the evasive maneuver at TB_7-plus-2400-seconds is to decrease the probability of S-IVB recontact and to avoid the ice particles expected to be expelled by the S-IVB during the LOX dump (TB_7-plus-7920-seconds). The magnitude of the evasive maneuver is 1.5 fps and requires approximately a 8-second, 4-jet RCS burn.

The direction of the evasive maneuver has not yet been determined but several maneuvers are being investigated. In choosing the ΔV direction, consideration will be given to:

1. SC and LV relative positions during the LOX blowdown.
2. LV and SC communications requirements.
3. Midcourse ΔV requirements.
4. Visual monitoring of the S-IVB during the blowdown.

It should be noted that the station keeping position is maintained for approximately 13 minutes. This time could be easily changed, since the period from 1610 to 3600 seconds (TB_7) is relatively void of activity.

The S-IVB assumes a local horizontal position for the LOX blowdown, with the +X-axis retrograde with respect to the direction of motion. The magnitude of the ΔV resulting from the LOX dump is expected to be approximately 90 ± 18 fps.

The LOX dump maneuver is designed to reduce the probability of SC recontact with the S-IVB and also to avoid S-IVB impact with the earth or moon. Nominally the LOX dump maneuver will result in a "sling-shot" trajectory; the S-IVB passes behind the trailing edge of the moon and is accelerated by the lunar gravitational field. The result is a heliocentric orbit which avoids either earth or lunar impact.

5.6 Translunar Coast

A ground track of the translunar coast phase is given in figure 2(b), and a time history of altitude for the first 4 hours of coast is provided in figure 3.

Passive thermal control attitude will be maintained throughout most of the translunar coast phase. A detailed timeline for the entire coast phase is currently being defined and will be published later.

Four midcourse correction maneuver points have been defined for the translunar coast phase with corresponding ΔV threshold values. The corrections will be performed if the predicted midcourse ΔV is greater than the threshold values. The times of these maneuver points and threshold values are as follows:

1.	TLI + 6 hours	3 fps
2.	TLI + 25 hours	1 fps
3.	LOI - 22 hours	1 fps
4.	LOI - 8 hours	1 fps

The maneuvers are GNCS-controlled using external ΔV guidance. Unless gimbal lock problems occur, the pad IMU alignment (REFSMMAT) will be used for the first three maneuvers and the LOI(2) preferred REFSMMAT for the last maneuver.

Preliminary dispersion analyses indicate that only three MC maneuvers will probably be required; (1), (2), and (4) or, (1), (3), and (4). It also appears that the 120 fps ΔV allowance used in the generation of the operational mission (table V) is somewhat conservative. More detailed MC information including the targeting procedures is contained in reference 6.

The CSM remains in sunlight during the entire translunar coast phase (table VI). The duration of the phase is $66^{h}12^{m}$.

Altitude above the lunar surface for the last 10 hours of translunar coast is provided in figure 4.

5.7 Lunar Orbit Insertion

The LOI burn (described below) is designed to insert the CSM into approximately a 60- by 170-n. mi. LPO. Figure 5 provides a time history

of trajectory parameters during the burn. The burn was simulated with the external ΔV guidance.

LOI initiation:	
Time, hr:min:sec, g.e.t.	69:07:29.2
Altitude, n. mi.	68.5
Selenographic latitude, deg	-7.2
Selenographic longitude, deg	-165.3
Burn duration, min:sec	4:05.8
Inertial burn arc, deg	16.3
Plane change, deg	2.4
ΔV, fps	2 991
SPS propellant used, lb	16 045
LOI burnout (Start LPO):	
Time, hr:min:sec, g.e.t.	69:11:35.0
Altitude, n. mi.	59.3
Selenographic latitude, deg	-10.0
Selenographic longitude, deg	178.4
Selenographic inclination, deg	167.7
Period of LPO, hr:min:sec	2:08:42
Altitude of pericynthion of LPO, n. mi.	59.0
Altitude of apocynthion of LPO, n. mi.	168.9

The preferred IMU alignment for the lunar orbit circularization burn LOI(2), was used for the LOI burn as well as for the TEI burn. The CSM is aligned heads-down and the engine is gimballed to account for the c.g. offset.

The target loads for the LOI burn are given in table X. More detailed information about the burn, including reset points, navigation updates, ignition gimbal angles, etc., is given in the "C Prime Simulator Data Package" (ref. 7).

The LOI burn parameters presented below were computed without simulating the SPS thrust buildup and tailoff. The effect of these, however, is reflected in the burn parameters presented in the simulation data package (ref. 7).

5.8 Lunar Orbit Circularization [LOI(2)]

A coplanar circularization burn is performed to place the CSM in approximately a 60-n. mi. circular LPO after two revolutions in the 60- by 170-n. mi. orbit. The target altitude of the orbit (60 n. mi.) is measured relative to the lunar target site (table II), and not to the mean lunar radius.

The burn is initiated near pericynthion of the second revolution. The preferred IMU alignment is used, and the CSM is orientated heads-down. More detailed information is given in reference 7. The characteristics of the burn are:

Circularization burn initiation:

Time, hr:min:sec, g.e.t.	73:30:52.8
Altitude, n. mi.	59.0
Selenographic latitude, deg	-10.8
Selenographic longitude, deg	169.6
Burn duration, sec	9.7
Inertial burn arc, deg	.5
ΔV, fps	138.5
SPS propellant used, lb	633.8

5.9 Lunar Orbit Coast

The LOI burn results in a 60- by 170-n. mi. elliptical lunar parking orbit. Near the end of the first revolution, general lunar photography is performed. Two revolutions, or abour 4 hours after LOI, the circularization burn is performed to place the CSM in a 60-n. mi.

circular orbit which will pass over the target site on the seventh revolution. On the first revolution after circularization (revolution 3), landmark training photography is performed on the approach to the target site. On the following sunrise, vertical stereo photography is initiated for most of the terminator to terminator pass. Just prior to the approach to the sunset terminator on revolution 4, a general landmark evaluation is made using the SCT. Beginning with revolution 5, the landmark tracking exercises are initiated. These include tracking of landmarks or control points on the back side of the moon and pseudo-landing site sightings near the Apollo landing sites. Two of these sightings are performed on revolutions 5 and 6 (one backside control point and one pseudo-landing site). On revolutions 7 and 8 three sightings are made on control points and one on the pseudo-landing site. This completes the landmark tracking exercises. On the sunrise following the last pseudo-landing site sighting, vertical stereo photography is performed from the terminator to terminator (into revolution 9). The remainder of revolutions 9 and 10 are devoted primarily to TEI preparation. TEI is performed near the end of revolution 10 or about 20 hours after LOI.

5.10 Transearth Injection

TEI occurs 19^h52^m after LOI. A time history of significant parameters during the burn is provided in figure 6. The burn was nominally targeted for an 82-hour transearth flight time. However, it may be desirable to reduce the flight time by 24 hours since no known constraints would be violated. Shorter flight times have been investigated and found acceptable in terms of ΔV requirements and entry conditions. The additional ΔV required to return 1 day early for the mission is approximately 694 fps. This additional ΔV results in a propellant penalty of approximately 2293 lb, the flight time 57.5 hours. Note that both burns occur on the back side of the moon. Trajectory parameters associated with both flight times are presented below.

The preferred IMU alignment for the circularization burn [LOI(2)] again was used for the TEI burn. Additional information concerning the nominal TEI (82-hour flight time) is contained in reference 7.

The characteristics of the nominal TEI burn and the burn after a one-day-earlier return are listed on the following page:

	Nominal	One day early
Initiation, hr:min:sec, g.e.t.	89:04:01.9	89:15:06.6
Latitude, deg	-2.95	-8.76
Longitude, deg	-151.0	177.5
Burn duration, sec	171.3	206.4
ΔV, fps	2 837.8	3 531.7
SPS propellant used, lb	11 180.4	13 473.3
Plane change	.2	1.5
Burnout		
Flight-path angle, deg	3.0	3.0
Altitude, n. mi.	61.2	59.9
Latitude, deg	-5.1	-10.8
Longitude, deg	-161.7	163.8
Entry velocity (inertial), fps	36 070.9	36 218.7

5.11 Transearth Coast

A ground track of the transearth coast phase (for the nominal TEI) is provided in figure 2(d). Altitude above the lunar surface for the first 10 hours of transearth coast is provided in figure 7. The flight time from TEI cutoff to entry interface is 81^h59^m.

As in the translunar coast phase, four MCC maneuver points have been defined:

1. TEI + 10 hours
2. TEI + 29 hours
3. Entry interface - 29 hours
4. Entry interface - 2 hours

For considerably shorter flight times such as that resulting from a return 1 day early (see section 5.10), only three midcourse maneuver points are defined:

1. TEI + 8 hours

2. TEI + 30 hours

3. TEI - 2 hours

These midcourse maneuvers are controlled by the GNCS using external ΔV guidance.

Unless gimbal lock is encountered, the REFSMMAT for the LPO circularization burn [LOI(2)] will be used for the first three maneuvers and the entry REFSMMAT for the last maneuver. For shorter flight times the LOI(2) REFSMMAT will be used for the first two and the entry REFSMMAT for the last.

A detailed timeline for the entire transearth coast phase is now being defined. This will define the attitude requirements for navigation sightings, communications, and thermal control. The complete attitude timeline will be published later.

Altitude versus time for the last 10 hours of transearth coast is provided in figure 8. CSM separation occurs 15 minutes prior to entry interface.

The vehicle remains in sunlight except for approximately the last 25 minutes of the transearth coast phase (table VII). S-band communications is lost (above 5° elevation) at approximately 3 minutes prior to entry interface (table VI). Additional coverage will be provided by the entry and injection tracking ships prior to and during entry.

5.12 Entry

The entry phase of the operational trajectory was simulated with the Apollo reentry simulation (ARS) program in six-degrees-of-freedom. Three-degrees-of-freedom trajectories were used to determine the CM maneuver footprint. Table XI shows the REFSMMAT and gimbal angles for entry.

The CM weight, c.g. position in the Apollo coordinate system, and moments and products of inertia (ref. 8) for the reentry interface are listed in table XII. Also included from the same reference are the CM weight at main parachute deployment and at splashdown. The reentry state vector is presented in table XIII, and the reentry corridor in figure 9.

The aerodynamic coefficients as a function of Mach number and angle of attack, which were used in the six-degrees-of-freedom trajectory simulation are from reference 9. These aerodynamic coefficients along with the corresponding coefficients of lift and drag for the three-degrees-of-freedom simulations were used to determine the CM maneuver footprint. Table XIV lists trim angles of attack, coefficients of lift and drag, and L/D as a function of Mach number.

Aerodynamics for the drogue and main parachute phase simulations consisted of drag values as a function of time from the initiation of the sequence. Drag values for parachutes are given in reference 9.

The atmospheric model used for the simulations was the 1962 U. S. Standard Atmosphere (ref. 10).

Figure 10 shows a plot of the CM maneuver footprint and the nominal ground trace on a map of the reentry area. The nominal touchdown target is 1350-n. mi. down range from the reentry interface. The coordinates of the target are 165° W longitude and 4.3° N geodetic latitude. The simulation uses the reentry guidance as defined in reference 11. Subsequent revisions to the guidance are explained in reference 12.

At the nominal reentry interface, $171^h5^m31.7^s$ g.e.t., the CM is at an altitude of 400 050 ft and the coordinates are 174.75° E longitude and 14.629° N geodetic latitude. Inertial velocity, flight-path angle, and azimuth at this point are 36 000 fps, -6.26°, and 112.595°, respectively.

The nominal mission time from lift-off to drogue deployment, at an altitude of 23 300 ft, is $171^h13^m55^s$. Figure 11, which shows altitude as a function of range to the target, denotes the guidance phases. The load factor at the c.g. reaches a first maximum of 5.46g, $171^h6^m57^s$ g.e.t., and a second maximum of 5.96g, $171^h11^m19^s$ g.e.t.

Time histories of the bank angle commanded by the guidance system, load factor, and altitude are presented in figure 12. The RCS system uses 12.11 lb of propellant for the separation and attitude hold maneuver prior to 0.05g. The RCS system then uses 19.5 lb of propellant performing the guidance commands during the remainder of the reentry. Figure 13 shows a time history of the RCS fuel consumption from 0.05g.

Figure 14 shows the time histories of the total heating rate and the total heat load. Time histories of velocity and flight-path angle, both inertial and relative, are presented in figure 15. The aerodynamic heating during reentry is an arithmetic sum of convective and radiative heating. The convective heating rate and the radiative heating rate

were determined as defined in references 13 and 14. The maximum total heating rate is 287.0 (B.t.u./ft^2)/sec at $171^h6^m42^s$ g.e.t., and the total heat is 27 569 B.t.u./ft^2. In figure 16, the altitude is plotted as a function of relative velocity, and the boundaries for S-band and C-band communication blackout are shown (ref. 15). Figure 17 shows the time histories of the primary DSKY displays, commanded bank angle, altitude rate, and inertial velocity. Table XV gives a sequence of pertinent events, including the periods of communication blackout, which occur along the trajectory.

The drogue chute deployment sequence starts at an altitude of 23 300 ft, $171^h13^m55^s$ g.e.t. Two seconds later, the two drogue parachutes are deployed. At an altitude of 10 500 ft, $171^h14^m48^s$ g.e.t, the low altitude baroswitch closes, and the drogue parachutes are disconnected. One second after the baroswitch closes, the three main parachutes are deployed. The CM, suspended on the main parachutes, reaches splashdown $171^h19^m18^s$ g.e.t. The relative velocity and relative flight-path angle versus time are plotted in figure 18 from drogue chute deployment. Figure 19 shows load factor and altitude versus time from drogue chute deployment.

An EMS scroll (nonexit pattern) is presented in figure 20(a) with the reference trajectory (from 0.05g) imposed upon it. The nonexit EMS pattern has limit lines which will prevent the spacecraft from exiting atmosphere ($g < 0.2$); therefore, when a tangency occurs in an offset or skip line, the spacecraft is in danger of skipping out of the atmosphere and a crew take-over is required. Another pattern will be available for the lunar mission which will allow the spacecraft to skip out of the atmosphere but not exceed a range of 3500 n. mi.

The commanded bank angle and EMS range-to-go versus the inertial velocity are plotted in figure 20(b).

6.0 TRACKING SHIP POSITIONS AND COVERAGE

The EPO insertion ship is located at a latitude 25° N and at a longitude 49° W. This location provides a minimum of 3-1/2 minutes of coverage after EPO insertion over the entire 36° azimuth spread for a minimum LOS elevation angle of 0°. It is understood that this minimum angle (0° for LOS) satisfies the ship requirement. Figure 21(a) shows the coverage provided. Note that the location is biased because of the better coverage provided by Antigua toward the latter part of the window.

Figure 21(b) shows the coverage for a minimum elevation angle at LOS of 5°.

Figure 21(c) shows the elevation angle at earth orbit insertion for the launch azimuth range.

The general guidelines used in establishing the TLI ship positions are as follows:

1. Coverage is optimized for the final 2 minutes of the S-IVB pre-ignition sequence.

2. The ships are positioned to cover the opening of the window whenever possible and coverage is continuous across the maximum possible launch azimuth range.

3. The coverage is maximized for the first injection opportunity.

4. The assumed cruising speed of the ships is 12 knots for repositioning on a day-to-day or month-to-month basis.

5. Coverage is based on a minimum elevation angle of 0°.

6. There was an attempt to provide coverage for the complete 36° launch azimuth range unless the window is restricted by the daylight launch constraint.

The positions of the two injection ships and the coverage which is provided are shown in table VIII(a) and (b). The coverage data are shown on bar graphs in terms of the launch azimuths for each launch date. Coverage for the first and second injection opportunities is given and the launch azimuth coverage common to both injection opportunities is identified. Coverage data and the duration of the launch window with the corresponding ship positions for each launch date are tabulated below the bar graphs.

The ship positions and the coverage provided for the December window are presented in table VIII(a). The TLI positions range from about 15° N latitude on December 20 to about 30° S latitude on December 27. A map showing the December TLI positions and the locations of the ships on each day is presented in figure 21(d).

The coverage available from the two ships is generally good for the first 3 days of the opportunity but begins to decrease thereafter due to the ship movement limitations. The island of New Guinea limits the movement of the westernmost ship and is the primary cause of the continually decreasing coverage that begins on December 24. The land mass of Australia prohibits ship placement to cover the opening of the window on the 27.

Some support is provided by the Guam MSFN station on the first 2 days, and the Carnarvon station provides assistance on the last 3 days.

The duration of the launch window for which coverage of the first injection opportunity is provided ranges from almost 4 hours on December 20 to only 10 minutes on December 26.

The ship positions and the coverage provided for the January window are presented in table VIII(b). The TLI maneuvers range from about 5° N latitude on January 18 to near 30° S latitude on January 24. A map showing the January TLI positions and the locations of the ships on each day is presented in figure 21(e).

The coverage available from the ships is good for the first day of the January window. The land mass of New Guinea restricts the movement of the ships beginning the second day. Consequently, the coverage available on the second and third days is reduced and launch window coverage is increased on subsequent days. The opening of the window is covered every day except January 23 when the land mass of Australia makes coverage of the opening impossible. Carnarvon station provides all or part of the coverage on the last 3 days of the window. The duration of the launch window for which coverage of the first injection opportunity is provided ranges from about 3-1/2 hours on January 18 to 10 minutes on January 22.

On days when it is practical, the entry ship will be initially placed to assist A/RIA in monitoring the TLI burn. After TLI the ship will cruise to the preplanned entry position. The entry ship positions are not yet available.

TABLE I.- LAUNCH WINDOW CONFIGURATION

Launch date	Target site	Time at opening of window[a], e.s.t., hr:min:sec	Launch window duration hr:min:sec	Selenographic approach azimuth to target site, deg	Range of sun elevation angles at passover site, deg
December 20 (1968)	I-P-1	6:05:00	04:43:28	-78.0	1.8 - 5.1
21	II-P-2	7:51:00	04:40:48	-78.0	6.6 - 10.0
22	II-P-6	09:25:39	04:38:56	-78.0	10.0 - 13.4
23	II-P-6	10:57:43	04:37:11	-78.0	24.0 - 27.3
24	II-P-8	12:21:23	04:36:38	-78.0	12.1 - 15.4
25	II-P-8	13:51:38	04:35:14	-78.0	26.0 - 29.3
26	II-P-11	15:15:47	4:34:32	-78.0	20.4 - 23.6
27	II-P-13	16:45:24	04:32:20	-82.0	12.0 - 15.2
January 18 (1969)	I-P-1	06:49:56	04:40:19	-80.0	-4.3 - (-1.0)
19	I-P-1	08:26:25	04:38:31	-81.0	9.5 - 12.9
20	II-P-2	09:58:33	04:36:32	-83.0	13.9 - 17.2
21	II-P-6	11:28:45	04:35:40	-83.0	17.3 - 20.5
22	II-P-8	12:58:28	04:34:44	-84.0	5.8 - 9.1
23	II-P-8	14:27:16	04:32:51	-83.0	19.2 - 22.3
24	III-P-9	15:52:48	04:30:43	-84.0	10.2 - 13.2

[a]Opening of window is for a 72° launch azimuth, closing for 108° launch azimuth.

TABLE II.- LUNAR TARGET SITE POSITIONS

Lunar target site no.	Selenographic latitude, deg	Selenographic longitude, deg	Altitude, n. mi.[a]
I-P-1	-1.2517	43.3014	-1.42
[b]II-P-2	2.6317	34.0253	-0.82
[b]II-P-6	0.7322	23.6475	-1.66
[b]II-P-8	0.3742	-1.3450	-0.50
[b]II-P-11	0.3255	-19.9003	-0.85
III-P-9	-3.0719	-23.5558	-1.21
[b]II-P-13	1.7667	-41.9389	-1.32

[a]Assumed mean lunar radius of 938.5 n. mi.

[b]Primary Apollo landing sites.

TABLE III.- SEQUENCE OF MAJOR EVENTS

[Launch occurs at $7^h50^m59.7^s$ e.s.t. on a 72° launch azimuth]

Mission phase	G.e.t., hr:min:sec	Data summary	
Earth orbit insertion	0:11:19.7	Latitude, deg N	32.7
		Longitude, deg W	-54.7
		Inclination, deg	32.6
Translunar injection	[a]2:50:31.2	Burn time, sec	311.5
		Plane change, deg	2.6
Free-return, circumlunar pericynthion	69:09:29.4	Altitude, n. mi.	60.2
		Selenographic latitude, deg	-9.1
		Longitude, deg	-174.8
Free-return entry	136:25:18.2	Altitude, n. mi.	65.8
		Longitude, deg	-37.8
		Latitude, deg	20.7
		Flight-path angle, deg	-6.7
		Velocity, fps	36 121.5
		Equatorial inclination, deg	28.4
		Vacuum perigee altitude, n. mi.	16.3
Lunar orbit insertion	69:07:29.2	Mass at ignition, lb	62 629.9
		Burn time, sec	245.8
		Plane change, deg	2.4
		Propellant used, lb	16 044.7
Circularization burn	[a]73:30:52.8	Mass at ignition, lb	45 565.2
		Burn time, sec	9.7
		Propellant used, lb	633.8
Pass over target site (7th rev.)	82:08:26.0	Sun elevation at site, deg	6.6
Transearth injection	89:04:01.8	Mass at ignition	45 666.4
		Burn time, sec	171.3
		Plane change, deg	0.2
		Propellant used, lb	11 180.4

[a]Ignition time

TABLE III.- SEQUENCE OF MAJOR EVENTS - Concluded

[Launch occurs at $7^h50^m59.7^s$ e.s.t. on a 72° launch azimuth]

Mission phase	G.e.t., hr:min:sec	Data summary	
Entry interface	171:05:31.7	Velocity, fps	36 070.9
		Flight-path angle, deg	-6.26
		Latitude, deg	14.6
		Longitude, deg . . .	174.7
Splashdown	171:19:18.3	Latitude, deg	4.28
		Longitude, deg . . .	-164.98

TABLE IV .- SPACECRAFT WEIGHT SUMMARY AND ENGINE CHARACTERISTICS

(a) Vehicle weights

CM inert, lb	12 392	
SM inert, lb	10 675	
SPS unusable, lb	666	
Total inert, lb		23 733
LTAB, lb		19 900
SPS deliverable (usable), lb		39 917
SLA, lb		4 150
Injected Saturn payload, lb		87 700

(b) Engine performance data

SPS engine 108 thrust, lbf	20 500
Nominal I_{SP}, lbf-sec/lbm	314.1
Minimum I_{SP}, lbf-sec/lbm	313.6

TABLE V.- ASSUMED MISSION

INDEPENDENT EXPENDABLES

Mission independent SPS ΔV budget	
Translunar, fps	120
Transearth, fps[a]	240
Other expendables	
Translunar coast, lb	272
Lunar orbit coast, lb	285
Transearth coast, lb	180

[a]Includes 178 fps for GNCS failure and return from any lunar orbit.

TABLE VI.- MISSION RADAR TIMELINE[a]

(a) Definitions of radar table headings[b]

MLA CB	Merritt Island C-band
PAT CB	Patrick C-band
KEN CB	Cape Kennedy C-band
GBI CB	Grand Bahama Island C-band
GTI CB	Grand Turk Island C-band
BDA CB	Bermuda C-band
ANT CB	Antigua C-band
CYI CB	Grand Canary C-band
ASC CB	Ascension Island C-band
PRE CB	Pretoria C-band
CAR CB	Carnarvon C-band
HAW CB	Hawaii C-band
CAL CB	Pt. Arguello C-band
WHS CB	White Sands C-band
EGL CB	Eglin C-band

[a]The enclosed radar table gives data for the coast phases only. If a station does not acquire or terminate at the nominal minimum elevation of 0° or 5°, the user must then investigate to see if the event took place because of exceeding maximum range, occulation, or end of a phase. All numbers are rounded off to the nearest unit of time, degrees, or nautical miles.

[b]Time is g.e.t. and range is slant range from the station to the spacecraft (n. mi.). See figure A-3b in the appendix for definitions of RA and DEC, figure A-3a for AZ and ELV, and figures A-3c and A-3d for X and Y. RA is equivalent to -HA in figure A-3b.

TABLE VI.- MISSION RADAR TIMELINE[a] - Continued

(a) Definitions of radar table headings[b] - Continued

TAN TM	Tananarive telemetry
KNO TM	Kano telemetry
MLA SB	Merritt Island S-band
GBI SB	Grand Bahama Island S-band
BDA SB	Bermuda S-band
ANT SB	Antigua S-band
CYI SB	Grand Canary S-band
ASC SB	Ascension S-band
CAR SB	Carnarvon S-band
GUM SB	Guam S-band
HAW SB	Hawaii S-band
GYM SB	Guaymas S-band
TEX SB	Corpus S-band
MAD DS	Madrid deep space
CNB DS	Canberra deep space
GLD DS	Goldstone deep space

[a]The enclosed radar table gives data for the coast phases only. If a station does not acquire or terminate at the nominal minimum elevation of 0° or 5°, the user must then investigate to see if the event took place because of exceeding maximum range, occulation, or end of a phase. All numbers are rounded off to the nearest unit of time, degrees, or nautical miles.

[b]Time is g.e.t. and range is slant range from the station to the spacecraft (n. mi.). See figure A-3b in the appendix for definitions of RA and DEC, figure A-3a for AZ and ELV, and figures A-3c and A-3d for X and Y. RA is equivalent to -HA in figure A-3b.

TABLE VI.- MISSION RADAR TIMELINE[a] - Continued

(a) Definitions of radar table headings[b] - Concluded

SHIP 1	Insertion ship
SHIP 2	Injection ship (1)
SHIP 3	Injection ship (2)

[a]The enclosed radar table gives data for the coast phases only. If a station does not acquire or terminate at the nominal minimum elevation of 0° or 5°, the user must then investigate to see if the event took place because of exceeding maximum range, occulation, or end of a phase. All numbers are rounded off to the nearest unit of time, degrees, or nautical miles.

[b]Time is g.e.t. and range is slant range from the station to the spacecraft (n. mi.). See figure A-3b in the appendix for definitions of RA and DEC, figure A-3a for AZ and ELV, and figures A-3c and A-3d for X and Y. RA is equivalent to -HA in figure A-3b.

TABLE VI.- MISSION RADAR TIMELINE - Continued

(b) 0° minimum elevation

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA											STATION TERMINATION DATA										
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
BDA SB	0	1	20	0	0	11	20	-52	8	85	7	83	5	541	0	0	12	40	-45	5	84	0	90	6	850
BDA CB	0	1	20	0	0	11	20	-52	8	85	7	83	5	541	0	0	12	40	-45	5	84	0	90	6	850
SHIP 1	0	4	12	0	0	11	20	119	55	+30	6	+78	59	555	0	0	15	32	-17	29	58	0	90	32	849
CYI SB	0	7	7	0	0	16	27	173	15	-73	0	-90	17	848	0	0	23	34	-8	-20	112	0	90	-22	841
CYI CB	0	7	7	0	0	16	27	173	15	-73	0	-90	17	848	0	0	23	34	-8	-20	112	0	90	-22	841
KNO TM	0	6	46	0	0	23	39	-165	45	-44	0	-90	46	838	0	0	30	25	26	-14	104	0	90	-14	832
TAN TM	0	5	32	0	0	36	59	-68	63	-19	0	-90	71	824	0	0	42	31	70	3	87	0	90	3	827
CAR CB	0	5	50	0	0	52	10	-54	-28	-121	0	+90	-31	834	0	0	58	0	158	-32	126	0	90	-36	834
CAR SB	0	5	50	0	0	52	10	-54	-28	-121	0	+90	-31	834	0	0	58	1	158	-32	126	0	90	-36	834
CNB DS	0	6	3	0	0	59	28	4	10	+78	0	-90	-78	832	0	1	5	31	146	37	42	0	-90	42	828
GYM SB	0	7	4	0	1	28	12	118	-25	-118	0	+90	-28	840	0	1	35	17	-67	13	76	0	90	14	848
CAL CB	0	4	15	0	1	28	19	166	-54	-169	0	+90	-79	838	0	1	32	34	-67	13	76	0	90	14	848
GLD DS	0	4	39	0	1	28	55	161	-51	-164	0	90	-16	838	0	1	33	33	-67	13	76	0	90	14	848
WHS CB	0	6	44	0	1	29	41	132	-31	-128	0	-90	-38	839	0	1	36	24	-69	0	89	0	90	1	847
TEX SB	0	7	3	0	1	31	5	121	-5	-95	0	-90	-5	844	0	1	38	9	-49	21	67	0	90	23	850
EGL CB	0	7	8	0	1	33	33	131	-2	-93	0	-90	-3	847	0	1	40	40	-42	12	76	0	90	14	850
MLA SB	0	6	53	0	1	34	58	131	10	+79	0	-90	11	848	0	1	41	52	-32	18	70	0	90	20	850
MLA CB	0	6	53	0	1	34	59	131	10	-78	0	-90	12	848	0	1	41	52	-32	18	70	0	90	20	850
KEN CB	0	6	53	0	1	35	0	131	10	-79	0	-90	11	848	0	1	41	53	-32	18	70	0	90	20	850
PAT CB	0	6	51	0	1	35	1	130	11	+78	0	+90	12	848	0	1	41	51	-32	18	70	0	90	20	850
GBI CB	0	6	30	0	1	35	42	129	19	+69	0	+90	21	849	0	1	42	12	-27	25	62	0	90	28	849
GBI SB	0	6	30	0	1	35	42	129	19	+69	0	-90	21	849	0	1	42	12	-26	25	62	0	90	28	850
BDA SB	0	7	10	0	1	38	25	150	4	-85	0	-90	5	850	0	1	45	35	-28	-4	95	0	90	+5	848
BDA CB	0	7	10	0	1	38	25	150	4	-85	0	-90	5	850	0	1	45	35	-28	-4	95	0	90	-5	848
GTI CB	0	4	16	0	1	38	31	119	49	+36	0	-90	54	849	0	1	42	46	-28	-4	95	0	90	-5	848

TABLE VI.- MISSION RADAR TIMELINE - Continued

(b) 0° minimum elevation - Continued

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA											STATION TERMINATION DATA										
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
SHIP 1	0	6	42	0	1	42	28	153	31	+56	0	+90	34	849	0	1	49	10	-6	6	84	0	90	6	845
CYI CB	0	5	20	0	1	50	0	-150	-9	-101	0	-90	-11	843	0	1	55	20	-27	-57	161	0	90	-71	835
CYI SB	0	5	20	0	1	50	0	-150	-9	-101	0	-90	-11	843	0	1	55	20	-27	-57	161	0	90	-71	835
KNO TM	0	5	36	0	1	57	1	-129	-2	+92	0	-90	-2	833	0	2	2	37	20	+68	162	0	90	-72	827
PRE CB	0	3	3	0	2	7	57	-1	63	7	0	90	83	824	0	2	10	60	60	27	60	0	90	30	826
TAN TM	0	6	51	0	2	9	5	-82	15	-74	0	-90	16	827	0	2	15	56	108	-35	127	0	90	-37	829
CAR SB	0	6	17	0	2	25	18	-35	-33	-127	0	-90	-37	834	0	2	31	34	171	-14	106	0	90	-16	833
CAR CB	0	6	16	0	2	25	18	-35	-33	-127	0	+90	-37	834	0	2	31	34	171	+14	106	0	90	-16	833
SHIP 2	0	6	10	0	2	44	21	67	-57	-148	0	-90	-58	828	0	2	50	31	-122	10	80	1	89	10	777
				TLI IGNITION 0 day 2 hr 50 min 32 sec																					
				TLI CUTOFF 0 day 2 hr 55 min 43 sec																					
HAW CB	0	1	41	0	2	55	43	-107	0	91	4	86	-1	887	0	2	57	24	-98	10	79	0	90	11	1399
HAW SB	0	1	41	0	2	55	43	-107	0	91	4	86	-1	887	0	2	57	24	-98	10	79	0	90	11	1399
CAL CB	2	24	18	0	2	56	40	135	-24	-120	0	+90	-30	1263	0	5	20	57	-43	2	98	15	75	-7	23400
GLD DS	13	28	3	0	2	57	4	137	-22	-117	0	90	-63	1336	0	16	25	6	-33	+6	-97	0	90	-83	78699
GYM SB	13	6	26	0	2	57	28	128	-3	+93	0	-90	-3	1415	0	16	3	54	-33	+6	-97	0	90	-83	78699
WHS CB	2	28	53	0	2	58	1	137	-9	-100	0	-90	-10	1523	0	5	26	54	-33	+6	-97	0	90	-83	78699
TEX SB	12	9	35	0	2	59	1	138	5	+85	0	-90	5	1730	0	15	8	37	-33	+6	-97	0	90	-83	78699
MLA SB	10	57	27	0	3	1	4	153	9	+80	0	-90	10	2171	0	13	58	30	-33	+6	-97	0	90	-83	78699
MLA CB	2	34	34	0	3	1	4	153	9	+80	0	-90	10	2172	0	5	35	39	-33	+6	-97	0	90	-83	78699
PAT CB	2	34	37	0	3	1	5	153	9	+80	0	-90	10	2175	0	5	35	42	-33	+6	-97	0	90	-83	78699
GBI CB	2	35	4	0	3	1	26	154	12	+77	0	+90	13	2252	0	5	36	31	-33	+6	-97	0	90	-83	78699
GBI SB	10	47	36	0	3	1	26	154	12	+77	0	-90	13	2253	0	13	49	3	-33	+6	-97	0	90	-83	78699
GTI CB	2	36	1	0	3	2	40	159	20	+68	0	-90	22	2523	0	5	38	41	-33	+6	-97	0	90	-83	78699
BDA SB	9	46	13	0	3	3	7	170	7	+81	0	-90	9	2626	0	12	49	20	-33	+6	-97	0	90	-83	78699
BDA CB	2	34	1	0	3	3	7	170	7	+81	0	-90	9	2626	0	5	37	8	-33	+6	-97	0	90	-83	78699
ANT CB	2	35	52	0	3	4	22	169	26	+63	0	-90	27	2702	0	5	40	14	-33	+6	-97	0	90	-83	78699

TABLE VI.- MISSION RADAR TIMELINE - Continued

(b) 0° minimum elevation - Continued

VEHICLE 1 RADAR TABLE	TRACKING TIME			STATION ACQUISITION DATA										STATION TERMINATION DATA									
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
ANT SB	9	38	27	0	3	4	23	169	26	-63	0	-90	27	2906	0	12	42	50	-33	-6	-97	0	90	-83	78699
SHIP 1	2	33	3	0	3	5	53	-178	17	-71	0	-90	19	3242	0	5	38	56	-33	-6	-97	0	90	-83	78699
CYI SB	6	6	21	0	3	13	8	-142	15	-73	0	-90	17	4813	0	9	19	29	-33	-6	-97	0	90	-83	78699
MAD DS	5	8	47	0	3	15	42	-129	8	-80	0	-90	-80	5350	0	8	24	29	-33	-6	-97	0	90	-83	78699
ASC CB	2	12	4	0	3	20	7	-126	35	-55	0	-90	35	6241	0	5	32	11	-33	-6	-97	0	90	-83	78699
ASC SB	5	56	58	0	3	20	8	-126	35	-55	0	-90	35	6246	0	9	17	6	-33	-6	-97	0	90	-83	78699
HAW SB	12	10	35	0	7	18	21	-37	0	90	0	90	0	36917	0	19	28	56	-31	-6	-97	0	-90	-7	89758
CNB DS	12	25	35	0	11	1	38	-32	0	90	0	90	90	56219	0	23	27	13	-29	-5	-96	0	90	-84	102812
GUM SB	11	57	10	0	11	24	14	-32	-3	93	0	90	-3	57956	0	23	21	24	-29	-5	-96	0	90	-84	102812
CAR SB	12	20	4	0	13	26	49	-30	-2	92	0	90	-2	66892	1	1	46	53	-28	-6	-97	0	-90	-7	109917
MAD DS	11	4	32	0	22	0	29	-27	-7	100	0	90	80	98205	1	9	5	1	-26	-9	-102	0	90	-78	130158
ASC SB	12	5	23	0	22	14	51	-26	-6	96	0	90	-6	98980	1	10	20	13	-26	-8	-98	0	-90	-8	133373
CYI SB	11	25	7	0	22	37	53	-26	-7	98	0	90	-8	100210	1	10	2	59	-26	-8	-98	0	-90	-8	133373
ANT SB	11	37	8	1	1	39	55	-25	-7	98	0	90	-8	109570	1	13	17	2	-25	-9	-99	0	-90	-9	140663
BDA SB	11	14	51	1	2	1	56	-25	-8	99	0	90	-9	110660	1	13	16	47	-25	-9	-99	0	-90	-9	140663
GBI SB	11	23	15	1	2	53	9	-25	-8	99	0	90	-9	113165	1	14	16	24	-25	-9	-100	0	-90	-10	143035
MLA SB	11	20	13	1	3	4	31	-25	-8	99	0	90	-9	113715	1	14	24	44	-25	-9	-100	0	-90	-10	143364
TEX SB	11	20	22	1	4	11	54	-25	-8	99	0	90	-9	116933	1	15	32	16	-25	-9	-101	0	-90	-11	146130
GYM SB	11	19	38	1	5	6	29	-24	-8	99	0	90	-9	119488	1	16	26	7	-25	-9	-101	0	-90	-11	148092
GLD DS	11	6	27	1	5	37	35	-24	-8	100	0	90	80	120923	1	16	44	2	-24	-10	-102	0	90	-78	148778
HAW SB	11	26	46	1	8	21	8	-24	-8	99	0	90	-9	128254	1	19	47	54	-24	-10	-100	0	-90	-10	155644
CNB DS	12	43	43	1	11	12	53	-23	-7	99	0	90	81	135583	1	23	56	36	-23	-9	-101	0	90	-79	164479
GUM SB	11	37	52	1	12	0	24	-23	-9	99	0	90	-9	137546	1	23	38	16	-23	-9	-101	0	90	-79	164479
CAR SB	12	27	50	1	13	42	6	-23	-8	99	0	90	-9	141671	2	2	9	56	-23	-9	-100	0	-90	-10	169017
MAD DS	10	44	8	1	22	25	59	-22	-10	103	0	90	77	161314	2	9	10	7	-22	-11	-104	0	90	-76	182598

TABLE VI.- MISSION RADAR TIMELINE - Continued

(b) 0° minimum elevation - Continued

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA										STATION TERMINATION DATA									
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	R_A	DEC	A_Z	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	R_A	DEC	A_Z	ELV	X	Y	RANGE
ASC SB	12	5	41	1	22	27	49	-21	-9	99	0	90	-9	161381	2	10	33	30	-22	-10	-100	0	-90	-10	185209
CYI SB	11	11	28	1	22	58	53	-21	-10	101	0	90	-11	162469	2	10	10	21	-22	-10	-100	0	-90	-10	185209
ANT SB	11	28	55	2	1	55	48	-21	-10	100	0	90	-10	168540	2	13	24	43	-22	-11	-101	0	-90	-11	190348
BDA SB	11	1	1	2	2	20	59	-21	-10	102	0	90	-12	169385	2	13	21	60	-22	-11	-101	0	-90	-11	190348
GBI SB	11	11	59	2	3	10	12	-21	-10	101	0	90	-11	171025	2	14	22	11	-22	-11	-102	0	-90	-12	192077
HLA SB	11	7	56	2	3	21	50	-21	-10	102	0	90	-12	171410	2	14	29	46	-22	-11	-103	0	-90	-13	192265
TEX SB	11	9	24	2	4	28	15	-21	-10	102	0	90	-12	173593	2	15	37	39	-22	-11	-103	0	-90	-13	194319
GYM SB	11	7	59	2	5	22	16	-21	-10	102	0	90	-12	175347	2	16	30	15	-22	-11	-103	0	-90	-13	195850
GLD DS	10	52	34	2	5	54	42	-21	-11	103	0	90	77	176391	2	16	47	16	-21	-11	-104	0	90	-76	196412
HAW SB	11	15	55	2	8	34	46	-20	-10	101	0	90	-11	181639	2	19	50	40	-22	-11	-102	0	-90	-12	201951
CNB DS	9	42	51	2	11	14	6	-20	-10	102	0	90	78	186384	2	20	56	57	-21	-11	-75	38	-19	-49	201923
GUM SB	8	46	51	2	12	10	11	-20	-11	101	0	90	-11	188104	2	20	57	3	-22	-12	-117	38	-49	-21	201949
CAR SB	7	11	59	2	13	44	55	-20	-10	101	0	90	-11	190928	2	20	56	54	-22	-12	-117	38	-49	-21	201949
				LOI IGNITION										2 day 21 hr 7 min 29 sec									
				LOI CUTOFF										2 day 21 hr 11 min 35 sec									
CAR SB	1	24	47	2	21	30	18	-21	-11	63	64	-24	12	200563	2	22	55	5	-20	-11	-79	46	-43	8	201435
CNB DS	1	24	47	2	21	30	19	-22	-11	81	31	-15	-57	201843	2	22	55	6	-21	-10	-92	15	9	-75	203032
GUM SB	1	24	43	2	21	30	31	-22	-12	-112	30	-58	-19	201914	2	22	55	13	-21	-11	-105	12	-78	-14	203220
ASC SB	0	23	1	2	22	31	36	-19	-11	101	0	90	-11	202731	2	22	54	37	-21	-11	-105	12	-78	-14	203220
MAD DS	0	18	13	2	22	36	35	-19	-12	105	0	90	75	202951	2	22	54	49	-21	-11	-105	12	-78	-14	203220
ASC SB	1	24	40	2	23	38	19	-19	-11	99	16	74	-9	202994	3	1	2	59	-18	-10	97	36	54	-6	202181
CYI SB	1	24	38	2	23	38	27	-19	-11	107	7	83	-17	203544	3	1	3	5	-18	-11	117	24	64	-25	202826
MAD DS	1	24	38	2	23	38	33	-19	-12	116	11	66	62	203281	3	1	3	11	-18	-11	131	24	56	43	202789
CNB DS	0	29	51	2	23	38	44	-21	-10	99	6	56	-80	203585	3	0	8	34	-18	-11	131	24	56	43	202789
CAR SB	1	24	41	2	23	38	44	-21	-11	85	36	54	4	201911	3	1	3	26	-20	-10	-93	18	-72	-3	203175
GUM SB	0	4	31	2	23	38	55	-21	-11	-102	1	-89	-12	203859	2	23	43	26	-20	-10	-93	18	-72	-3	203175

TABLE VI.- MISSION RADAR TIMELINE - Continued

(b) 0° minimum elevation - Continued

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA											STATION TERMINATION DATA										
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
CIRCULARIZATION BURN IGNITION															3 day 1 hr 30 min 53 sec										
CIRCULARIZATION BURN CUTOFF															3 day 1 hr 31 min 3 sec										
ASC SB	1	11	31	3	1	47	52	-18	-10	97	47	43	-5	201684	3	2	59	23	-17	-10	96	64	26	-3	201278
CYI SB	1	11	29	3	1	47	60	-18	-11	126	32	52	-30	202366	3	2	59	29	-17	-10	141	43	33	-35	201996
MAD DS	1	11	30	3	1	48	3	-18	-11	142	30	54	32	202461	3	2	59	33	-18	-11	161	37	51	15	202296
CAR SB	0	34	19	3	1	48	12	-20	-10	-98	7	83	-8	203738	3	2	22	31	-18	-11	161	37	51	15	202296
ANT SB	0	53	45	3	2	5	30	-18	-11	101	0	90	-11	203351	3	2	59	15	-18	-11	161	37	51	15	202296
BDA SB	0	26	42	3	2	32	39	-17	-11	102	0	90	-12	203087	3	2	59	21	-18	-11	161	37	51	15	202296
GBI SB	1	11	51	3	3	45	55	-17	-10	104	5	85	-14	204170	3	4	57	46	-16	-10	113	20	69	-21	203473
ANT SB	1	11	50	3	3	45	55	-17	-10	109	23	66	-18	203158	3	4	57	45	-16	-10	113	20	69	-21	203473
MLA SB	1	11	49	3	3	45	56	-17	-10	103	3	87	-13	204323	3	4	57	46	-16	-10	113	20	69	-21	203473
BDA SB	1	11	52	3	3	45	57	-17	-10	113	15	74	-22	203611	3	4	57	49	-16	-10	124	28	58	-30	203050
ASC SB	1	11	52	3	3	46	1	-18	-10	99	76	14	-2	201168	3	4	57	53	-17	-9	-116	87	-3	-1	201240
CYI SB	1	11	50	3	3	46	8	-18	-10	156	49	19	-37	201899	3	4	57	58	-17	-10	-177	52	-2	-38	201944
MAD DS	1	11	44	3	3	46	16	-18	-11	175	39	51	4	202324	3	4	57	60	-17	-10	-163	38	51	-13	202540
TEX SB	0	15	45	3	4	41	58	-16	-10	101	0	90	-11	203791	3	4	57	43	-17	-10	-163	38	51	-13	202540
GYM SB	1	11	31	3	5	44	24	-16	-10	102	2	88	-12	204646	3	6	55	55	-15	-9	110	16	72	-20	203937
TEX SB	1	11	30	3	5	44	26	-16	-10	109	13	76	-18	203962	3	6	55	57	-15	-9	119	27	59	-25	203333
GBI SB	1	11	34	3	5	44	28	-16	-10	120	29	57	-26	203072	3	6	56	2	-15	-9	134	42	39	-31	202628
MLA SB	1	11	30	3	5	44	29	-16	-10	119	27	60	-26	203221	3	6	55	58	-15	-9	134	42	39	-31	202628
ANT SB	1	11	32	3	5	44	30	-16	-10	127	48	36	-24	202225	3	6	56	2	-15	-9	148	59	18	-26	201979
BDA SB	1	11	32	3	5	44	32	-16	-10	135	35	45	-35	202764	3	6	56	4	-15	-9	153	44	25	-40	202521
ASC SB	1	11	34	3	5	44	40	-17	-9	-97	75	-15	-2	201445	3	6	56	14	-16	-9	-94	58	-32	-2	202024
CYI SB	1	11	35	3	5	44	42	-17	-10	-159	50	17	-37	202119	3	6	56	17	-16	-9	-137	42	-37	-33	202621
MAD DS	1	11	35	3	5	44	46	-17	-10	-149	34	52	-25	202805	3	6	56	21	-16	-10	-132	27	53	-42	203396
GLD DS	0	47	45	3	6	8	9	-16	-10	102	0	90	78	203688	3	6	55	54	-16	-10	-132	27	53	-42	203396
GYM SB	1	11	46	3	7	42	31	-15	-9	118	26	61	-25	203546	3	8	54	17	-14	-9	131	39	43	-31	203052
TEX SB	1	11	51	3	7	42	31	-15	-9	128	36	47	-30	203026	3	8	54	22	-14	-9	145	47	28	-34	202697

TABLE VI.- MISSION RADAR TIMELINE - Continued

(b) 0° minimum elevation - Continued

VEHICLE	1 RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA										STATION TERMINATION DATA									
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
GLD DS	1	11	46	3	7	42	32	-15	-10	116	18	54	59	203991	3	8	54	18	-14	-9	145	47	28	-34	202697
GBI SB	1	11	47	3	7	42	39	-15	-9	148	49	25	-34	202474	3	8	54	26	-15	-9	174	54	5	-35	202431
ANT SB	1	11	47	3	7	42	42	-16	-9	171	63	5	-26	201985	3	8	54	29	-15	-9	-152	61	-14	-25	202217
MLA SB	1	11	42	3	7	42	43	-15	-9	146	46	29	-35	202583	3	8	54	25	-15	-9	-152	61	-14	-25	202217
BDA SB	1	11	43	3	7	42	48	-16	-10	170	48	9	-42	202506	3	8	54	31	-15	-9	-165	48	-13	-41	202685
ASC SB	1	11	44	3	7	42	52	-16	-9	-95	46	-43	-3	202553	3	8	54	35	-16	-8	-95	30	-60	-4	203529
CYI SB	1	11	38	3	7	42	58	-16	-9	-126	34	-50	-29	203088	3	8	54	36	-15	-9	-113	22	-67	-22	203950
MAD DS	1	11	39	3	7	43	0	-16	-10	-122	19	57	-53	203885	3	8	54	39	-15	-9	-109	8	67	-69	204734
HAW SB	0	1	41	3	8	52	30	-14	-9	99	0	90	-9	205105	3	8	54	12	-15	-9	-109	8	67	-69	204734
HAW SB	1	11	31	3	9	40	55	-14	-9	104	11	79	-14	204661	3	10	52	26	-13	-8	112	26	62	-20	203955
GYM SB	1	11	34	3	9	41	4	-14	-9	143	46	30	-34	202848	3	10	52	37	-14	-8	167	53	9	-36	202752
GLD DS	1	11	34	3	9	41	4	-14	-9	141	37	46	31	203252	3	10	52	39	-14	-8	161	49	44	14	203090
TEX SB	1	11	40	3	9	41	6	-15	-9	162	52	14	-36	202619	3	10	52	46	-14	-8	-170	53	-7	-36	202738
MLA SB	1	11	37	3	9	41	11	-15	-9	-171	52	-7	-37	202605	3	10	52	47	-14	-8	-146	47	-28	-34	202986
GBI SB	1	11	36	3	9	41	13	-15	-9	-166	54	-10	-35	202553	3	10	52	49	-14	-8	-141	47	-30	-32	202979
ANT SB	1	11	39	3	9	41	14	-15	-9	-134	54	-27	-24	202528	3	10	52	52	-14	-8	-118	41	-45	-21	203235
BDA SB	1	11	40	3	9	41	14	-15	-9	-149	44	-28	-38	202941	3	10	52	53	-14	-8	-131	35	-48	-32	203542
ASC SB	1	11	39	3	9	41	15	-16	-8	-96	18	-72	-6	204251	3	10	52	55	-15	-8	-98	1	-89	-8	205432
CYI SB	0	59	26	3	9	41	21	-16	-9	-107	12	-78	-16	204596	3	10	40	47	-15	-8	-98	1	-89	-8	205432
HAW SB	1	11	42	3	11	39	8	-13	-8	119	36	50	-23	203585	3	12	50	50	-12	-8	134	49	32	-27	203169
GYM SB	1	11	38	3	11	39	24	-14	-8	-173	53	-5	-36	202846	3	12	51	3	-13	-8	-147	49	-26	-34	203207
GLD DS	1	11	36	3	11	39	25	-14	-9	177	46	44	2	203123	3	12	51	1	-13	-8	-147	49	-26	-34	203207
TEX SB	1	11	38	3	11	39	26	-14	-8	-152	50	22	-35	202969	3	12	51	4	-13	-8	-131	41	-41	-30	203531
GBI SB	1	11	38	3	11	39	31	-14	-8	-129	40	-43	-29	203402	3	12	51	8	-13	-8	-115	27	-61	-22	204219
MLA SB	1	11	36	3	11	39	32	-14	-8	-132	40	-41	-31	203380	3	12	51	8	-13	-8	-118	28	-59	-24	204160

TABLE VI.- MISSION RADAR TIMELINE - Continued

(b) 0° minimum elevation - Continued

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA											STATION TERMINATION DATA										
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
ANT SB	1	11	34	3	11	39	35	-15	-8	-111	31	-57	-18	203823	3	12	51	9	-14	-8	-103	16	-74	-13	204857
BDA SB	1	11	34	3	11	39	36	-14	-8	-121	27	-60	-27	204049	3	12	51	9	-14	-8	-109	14	-75	-18	204956
CNB DS	1	5	5	3	11	45	32	-13	-7	99	0	90	81	205288	3	12	50	37	-14	-8	-109	14	-75	-18	204956
GUM SB	0	15	57	3	12	34	43	-12	-8	98	0	90	-8	204899	3	12	50	41	-14	-8	-109	14	-75	-18	204956
CNB DS	1	11	36	3	13	37	18	-12	-7	83	22	-18	67	204617	3	14	48	54	-11	-6	71	35	-26	51	204071
GUM SB	1	11	31	3	13	37	25	-12	-8	102	15	75	-11	204991	3	14	48	56	-11	-7	107	31	58	-14	204254
HAW SB	1	11	41	3	13	37	35	-13	-8	150	56	18	-29	203034	3	14	49	16	-12	-7	-178	61	-1	-29	203067
GLD DS	1	11	45	3	13	37	44	-13	-8	-144	40	44	-27	203677	3	14	49	30	-12	-7	-127	30	46	-44	204328
GYM SB	1	11	44	3	13	37	46	-13	-8	-133	42	-39	-31	203584	3	14	49	30	-12	-7	-118	30	-57	-24	204355
TEX SB	1	11	47	3	13	37	47	-13	-8	-121	32	-54	-26	204027	3	14	49	34	-13	-7	-109	19	-70	-18	204944
MLA SB	1	11	47	3	13	37	49	-14	-8	-110	19	-70	-19	204765	3	14	49	35	-13	-7	-101	4	-85	-11	205793
GBI SB	1	11	47	3	13	37	49	-14	-8	-108	17	-72	-18	204847	3	14	49	35	-13	-7	-101	4	-85	-11	205793
BDA SB	0	21	32	3	13	37	50	-14	-8	-102	4	-86	-12	205607	3	13	59	21	-13	-7	-101	4	-85	-11	205793
ANT SB	0	19	56	3	13	37	50	-14	-8	-99	4	-85	-9	205592	3	13	57	46	-13	-7	-101	4	-85	-11	205793
CAR SB	0	26	54	3	14	21	53	-11	-7	97	0	90	-7	204764	3	14	48	48	-13	-7	-101	4	-85	-11	205793
CAR SB	1	11	33	3	15	35	32	-11	-7	90	16	74	0	205201	3	16	47	4	-10	-6	81	32	58	7	204513
CNB DS	1	11	34	3	15	35	37	-11	-6	60	44	-27	39	203802	3	16	47	11	-11	-6	40	54	-29	22	203546
GUM SB	1	11	33	3	15	35	44	-11	-7	113	42	46	-17	203866	3	16	47	17	-10	-7	126	57	28	-18	203449
HAW SB	1	11	30	3	15	36	0	-12	-7	-155	58	-15	-29	203248	3	16	47	31	-11	-7	-131	49	-33	-26	203753
GLD DS	1	11	27	3	15	36	10	-13	-7	-117	22	49	-55	204851	3	16	47	37	-12	-7	-106	10	58	-72	205764
TEX SB	0	44	33	3	15	36	10	-13	-7	-103	9	-81	-13	205605	3	16	20	44	-12	-7	-106	10	58	-72	205764
GYM SB	1	11	26	3	15	36	12	-13	-7	-110	20	-69	-19	204952	3	16	47	37	-12	-7	-101	6	-84	-11	205969
				TEI IGNITION 3 day 17 hr 4 min 2 sec																					
				TEI CUTOFF 3 day 17 hr 6 min 53 sec																					
CAR SB	9	19	25	3	17	21	14	-10	-6	77	39	50	10	204890	4	2	40	39	-12	-6	-97	0	-90	-7	196223
CNB DS	7	4	33	3	17	21	18	-11	-6	26	58	-29	13	204166	4	0	25	51	-12	-6	-97	0	-90	-7	196223
GUM SB	6	57	5	3	17	21	24	-11	-7	138	63	19	-19	204009	4	0	18	30	-12	-6	-97	0	-90	-7	196223

TABLE VI.- MISSION RADAR TIMELINE - Continued

(b) 0° minimum elevation - Continued

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA											STATION TERMINATION DATA										
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
HAW SB	3	10	5	3	17	21	35	-12	-7	-123	42	-43	-24	204764	3	20	31	40	-12	-6	-97	0	-90	-7	196223
GLD DS	0	12	1	3	17	21	38	-12	-7	-100	3	76	-79	206912	3	17	33	40	-12	-6	-97	0	-90	-7	196223
MAD DS	11	5	42	3	22	52	23	-11	-7	100	0	90	80	200649	4	9	58	5	-11	-7	-99	0	90	-81	187207
ASC SB	12	0	10	3	23	5	19	-10	-7	97	0	90	-7	200402	4	11	5	29	-12	-6	-96	0	-90	-6	185736
CYI SB	11	24	45	3	23	28	35	-10	-7	98	0	90	-8	199953	4	10	53	20	-12	-6	-96	0	-90	-6	185736
ANT SB	11	37	33	4	2	27	1	-10	-7	97	0	90	-7	196491	4	14	4	33	-11	-6	-97	0	-90	-7	181696
BDA SB	11	19	24	4	2	48	7	-10	-7	98	0	90	-8	196066	4	14	7	31	-11	-7	-98	0	-90	-8	181627
GBI SB	11	27	5	4	3	38	36	-10	-7	98	0	90	-8	195070	4	15	5	41	-11	-7	-97	0	-90	-7	180274
MLA SB	11	24	45	4	3	49	43	-10	-7	98	0	90	-8	194844	4	15	14	28	-11	-7	-98	0	-90	-8	180068
TEX SB	11	26	11	4	4	55	54	-10	-7	98	0	90	-8	193471	4	16	22	5	-11	-7	-97	0	-90	-7	178476
GYM SB	11	25	56	4	5	49	40	-10	-7	98	0	90	-8	192417	4	17	15	36	-11	-6	-97	0	-90	-7	177174
GLD DS	11	16	16	4	6	19	21	-10	-7	99	0	90	81	191806	4	17	35	37	-11	-7	-98	0	90	-82	176686
HAW SB	11	33	36	4	9	2	10	-10	-7	97	0	90	-7	188412	4	20	35	46	-10	-6	-97	0	-90	-7	172182
CNB DS	12	26	24	4	12	0	37	-9	-6	97	0	90	83	184513	5	0	27	1	-10	-5	-96	0	90	-84	166066
GUM SB	11	42	59	4	12	40	44	-9	-6	97	0	90	-7	183617	5	0	23	43	-10	-5	-96	0	90	-84	166066
CAR SB	12	15	11	4	14	28	17	-9	-6	96	0	90	-6	181148	5	2	43	28	-10	-5	-95	0	-90	-5	162267
MAD DS	11	15	40	4	22	54	31	-8	-6	98	0	90	82	168557	5	10	10	11	-8	-6	-98	0	90	-82	148744
ASC SB	12	0	49	4	23	11	19	-8	-5	96	0	90	-6	168111	5	11	12	8	-9	-5	-95	0	-90	-5	146727
CYI SB	11	31	40	4	23	32	16	-8	-6	97	0	90	-7	167548	5	11	3	56	-9	-5	-95	0	-90	-5	146727
ANT SB	11	42	34	5	2	32	24	-7	-6	96	0	90	-6	162580	5	14	14	58	-8	-5	-95	0	-90	-5	140543
BDA SB	11	28	5	5	2	51	54	-8	-6	97	0	90	-7	162026	5	14	19	60	-8	-5	-96	0	-90	-6	140368
GBI SB	11	34	25	5	3	43	19	-7	-6	97	0	90	-7	160553	5	15	17	44	-8	-5	-96	0	-90	-6	138339
MLA SB	11	32	38	5	3	54	12	-7	-6	97	0	90	-7	160239	5	15	26	49	-8	-5	-96	0	-90	-6	138016
TEX SB	11	33	57	5	5	0	51	-7	-6	97	0	90	-7	158291	5	16	34	48	-8	-5	-96	0	-90	-6	135573
GYM SB	11	34	3	5	5	54	41	-7	-6	97	0	90	-7	156691	5	17	28	44	-7	-5	-95	0	-90	-5	133596

TABLE VI.- MISSION RADAR TIMELINE - Continued

(b) 0° minimum elevation - Concluded

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA											STATION TERMINATION DATA										
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
GLD DS	11	26	30	5	6	23	38	-7	-6	97	0	90	83	155820	5	17	50	8	-7	-5	-96	0	90	-84	132802
HAW SB	11	40	33	5	9	9	2	-6	-5	96	0	90	-6	150764	5	20	49	36	-7	-4	-95	0	-90	-5	125922
CNB DS	12	16	43	5	12	15	40	-6	-4	95	0	90	85	144618	6	0	32	23	-6	-2	-93	0	90	-87	116773
GUM SB	11	48	33	5	12	49	38	-6	-5	95	0	90	-5	143472	6	0	38	10	-6	-4	-94	0	-90	-4	116525
CAR SB	12	9	29	5	14	42	45	-5	-4	94	0	90	-4	139574	6	2	52	14	-5	-2	-92	0	-90	-2	110642
MAD DS	11	37	12	5	23	3	3	-4	-5	96	0	90	84	120526	6	10	40	15	-2	-3	-94	0	90	-86	87399
ASC SB	12	2	23	5	23	28	11	-3	-3	93	0	90	-3	119483	6	11	30	33	-3	-1	-91	0	-90	-1	84593
CYI SB	11	47	47	5	23	43	38	-3	-4	95	0	90	-5	118836	6	11	31	25	-2	-2	-93	0	-90	-3	84544
ANT SB	11	57	17	6	2	47	31	-2	-4	94	0	90	-4	110853	6	14	44	48	-1	-1	-91	0	-90	-1	73019
BDA SB	11	50	54	6	3	4	17	-2	-4	95	0	90	-5	110097	6	14	55	11	0	-2	-92	0	-90	-2	72364
GBI SB	11	55	42	6	3	57	28	-2	-4	94	0	90	-4	107668	6	15	53	10	0	-1	-91	0	-90	-1	68621
MLA SB	11	55	17	6	4	8	5	-2	-4	94	0	90	-4	107177	6	16	3	22	0	-1	-91	0	-90	-1	67948
TEX SB	11	58	32	6	5	15	44	-1	-3	94	0	90	-4	103998	6	17	14	16	1	-1	-91	0	-90	-1	63138
GYM SB	12	1	10	6	6	10	15	-1	-3	94	0	90	-4	101372	6	18	11	25	2	0	-90	0	-90	0	59077
GLD DS	11	59	57	6	6	37	48	-1	-3	94	0	90	86	100021	6	18	37	45	2	0	-91	0	90	-89	57144
HAW SB	12	17	56	6	9	29	8	1	-3	93	0	90	-3	91249	6	21	47	4	6	2	-88	0	-90	2	41787
CNB DS	12	3	22	6	12	59	2	3	1	89	0	-90	89	79477	7	1	2	24	16	16	-70	0	-90	-70	21368
GUM SB	13	45	27	6	13	17	53	3	-1	91	0	90	-1	78354	7	3	3	20	-145	20	70	0	90	20	1166
CAR SB	11	20	42	6	15	29	2	5	1	89	0	90	1	70196	7	2	49	44	-145	20	70	0	90	20	1166
MAD DS	1	44	54	7	0	26	51	25	4	85	0	890	85	25674	7	2	11	46	-145	20	70	0	90	20	1166
TAN TM	2	10	30	7	0	28	20	24	12	55	40	45	26	23400	7	2	38	50	-145	20	70	0	90	20	1166
CAR CB	2	21	12	7	0	28	32	16	13	-46	39	-42	33	23400	7	2	49	45	-145	20	70	0	90	20	1166
PRE CB	1	47	24	7	0	36	21	27	13	63	20	68	25	23400	7	2	23	45	-145	20	70	0	90	20	1166

ENTRY INTERFACE 7 day 3 hr 5 min 32 sec

TABLE VI.- MISSION RADAR TIMELINE - Continued

(c) 5° minimum elevation

VEHICLE 1 RADAR TABLE

	TRACKING TIME			STATION ACQUISITION DATA											STATION TERMINATION DATA										
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
BDA SB	0	0	16	0	0	11	20	-52	8	85	7	83	5	541	0	0	11	35	-50	7	85	5	85	5	601
BDA CB	0	0	16	0	0	11	20	-52	8	85	7	83	5	541	0	0	11	35	-50	7	85	5	85	5	601
SHIP 1	0	2	44	0	0	11	20	119	55	-30	6	+78	59	555	0	0	14	4	-11	48	39	5	82	51	601
CYI SB	0	4	58	0	0	17	32	178	17	+73	5	+85	16	599	0	0	22	30	-13	-18	113	5	85	-23	594
CYI CB	0	4	58	0	0	17	32	178	17	-73	5	-85	16	599	0	0	22	30	-13	-18	113	5	85	-23	594
KNO TM	0	4	30	0	0	24	47	-160	54	-36	5	+82	54	590	0	0	29	17	22	-6	97	5	85	-7	586
TAN TM	0	2	22	0	0	38	34	-10	66	4	5	40	83	578	0	0	40	56	56	23	63	5	84	27	579
CAR SB	0	2	53	0	0	53	39	-61	-48	-141	5	-82	-51	587	0	0	56	32	167	-52	146	5	81	-56	587
CAR CB	0	2	53	0	0	53	39	-61	-48	-141	5	-82	-51	587	0	0	56	32	167	-52	146	5	81	-56	587
CNB DS	0	3	24	0	1	0	48	18	19	-62	5	-79	-62	584	0	1	4	12	125	42	26	5	-84	26	582
GYM SB	0	4	55	0	1	29	17	125	-24	-121	5	-84	-31	594	0	1	34	11	-73	13	78	5	85	12	599
WHS CB	0	4	25	0	1	30	50	143	-34	-136	5	-83	-46	593	0	1	35	15	-78	-4	98	5	85	+8	597
TEX SB	0	4	52	0	1	32	11	123	2	-91	5	+85	-1	597	0	1	37	3	-51	27	62	5	84	28	600
EGL CB	0	4	52	0	1	34	37	134	3	-90	5	-85	0	599	0	1	39	29	-45	17	74	5	85	16	602
MLA SB	0	4	36	0	1	36	7	132	19	-71	5	-85	19	600	0	1	40	43	-33	27	62	5	84	28	601
MLA CB	0	4	35	0	1	36	8	131	19	+71	5	+85	19	600	0	1	40	43	-33	27	62	5	84	28	601
KEN CB	0	4	36	0	1	36	9	132	19	-71	5	+85	19	600	0	1	40	45	-33	27	62	5	84	28	601
PAT CB	0	4	32	0	1	36	10	131	21	+69	5	-85	21	600	0	1	40	42	-33	27	62	5	84	28	601
GBI CB	0	3	60	0	1	36	57	127	33	-56	5	-84	34	600	0	1	40	57	-25	38	50	5	83	40	601
GBI SB	0	3	60	0	1	36	57	127	33	+56	5	+84	34	600	0	1	40	57	-24	38	50	5	83	40	601
SHIP 1	0	4	19	0	1	43	40	153	42	+46	5	-83	44	600	0	1	47	59	-7	17	74	5	85	16	597
CYI CB	0	1	39	0	1	51	51	-129	-32	-130	5	-83	-40	592	0	1	53	30	-83	+56	-169	5	-66	-78	590
CYI SB	0	1	39	0	1	51	51	-128	-32	-130	5	+83	-40	592	0	1	53	30	-83	+56	-169	5	+66	-78	590
KNO TM	0	2	27	0	1	58	36	-118	-23	-115	5	-85	-24	584	0	2	1	2	-54	+72	-175	5	-44	-83	581
TAN TM	0	4	40	0	2	10	10	-79	8	679	5	+85	11	580	0	2	14	50	104	-41	132	5	83	-42	581

TABLE VI.- MISSION RADAR TIMELINE - Continued

(c) 5° minimum elevation - Continued

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA										STATION TERMINATION DATA									
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
CAR SB	0	3	42	0	2	26	35	-38	-48	-141	5	-82	-51	586	0	2	30	17	173	-29	120	5	84	-30	586
CAR CB	0	3	42	0	2	26	35	-39	-48	-142	5	-82	-51	586	0	2	30	17	173	-29	120	5	84	-30	586
SHIP 2	0	4	2	0	2	45	33	86	-66	-159	5	-76	-68	582	0	2	49	35	-128	1	89	5	85	1	585
							TLI IGNITION				0 day	2 hr	50 min	32 sec											
							TLI CUTOFF				0 day	2 hr	50 min	32 sec											
CAL CB	2	23	42	0	2	57	15	141	-23	-123	5	-84	-33	1105	0	5	20	57	-43	2	98	15	75	-7	23900
GLD DS	13	1	52	0	2	57	40	143	-21	-120	5	80	-60	1181	0	15	59	32	-33	-6	-101	5	65	-78	76778
GYM SB	12	42	12	0	2	58	3	132	0	-92	5	-85	-2	1260	0	15	40	15	-33	-6	-101	5	65	-78	76778
WHS CB	2	28	17	0	2	58	37	141	-6	-101	5	-85	-11	1372	0	5	26	54	-33	-6	-101	5	65	-78	76778
TEX SB	11	45	18	0	2	59	39	142	8	-84	5	-85	6	1588	0	14	44	58	-33	-6	-101	5	65	-78	76778
MLA SB	10	32	45	0	3	1	46	157	11	-80	5	-85	10	2046	0	13	34	31	-33	-6	-101	5	65	-78	76778
MLA CB	2	33	52	0	3	1	47	157	11	-80	5	-85	10	2047	0	5	35	39	-33	-6	-101	5	65	-78	76778
PAT CB	2	33	54	0	3	1	47	157	12	-79	5	-85	11	2050	0	5	35	42	-33	-6	-101	5	65	-78	76778
GBI CB	2	34	21	0	3	2	10	159	15	-76	5	-85	14	2131	0	5	36	31	-33	-6	-101	5	65	-78	76778
GBI SB	10	23	15	0	3	2	10	159	15	-76	5	-85	14	2132	0	13	25	25	-33	-6	-101	5	65	-78	76778
GTI CB	2	35	13	0	3	3	27	164	23	-67	5	-85	23	2417	0	5	38	41	-33	-6	-101	5	65	-78	76778
BDA SB	9	20	17	0	3	3	56	174	9	-82	5	-85	8	2524	0	12	24	13	-33	-6	-101	5	65	-78	76778
BDA CB	2	33	12	0	3	3	56	174	9	-82	5	-85	8	2524	0	5	37	8	-33	-6	-101	5	65	-78	76778
ANT CB	2	34	58	0	3	5	16	174	28	-62	5	-84	28	2818	0	5	40	14	-33	-6	-101	5	65	-78	76778
ANT SB	9	15	11	0	3	5	17	174	29	-62	5	-84	28	2822	0	12	20	29	-33	-6	-101	5	65	-78	76778
SHIP 1	2	32	3	0	3	6	53	-173	19	-72	5	-85	18	3176	0	5	38	56	-33	-6	-101	5	65	-78	76778
CYI SB	5	39	10	0	3	14	57	-136	16	-75	5	-85	15	4904	0	8	54	7	-33	-6	-101	5	65	-78	76778
MAD DS	4	36	16	0	3	18	17	-122	8	-83	5	-54	-81	5586	0	7	54	33	-33	-6	-101	5	65	-78	76778
ASC CB	2	9	24	0	3	22	46	-119	34	-54	5	-84	36	6475	0	5	32	11	-33	-6	-101	5	65	-78	76778
ASC SB	5	30	34	0	3	22	48	-119	34	-54	5	-84	36	6480	0	8	53	22	-33	-6	-101	5	65	-78	76778
HAW SB	11	22	51	0	7	43	43	-36	0	93	5	85	-3	39059	0	19	6	34	-31	-6	-99	5	-85	-9	88164
CNB DS	11	35	1	0	11	26	38	-32	0	87	5	-34	84	57840	0	23	1	39	-29	-5	-93	5	29	-84	101172

TABLE VI.- MISSION RADAR TIMELINE - Continued

(c) 5° minimum elevation - Continued

VEHICLE 1 RADAR TABLE	TRACKING TIME			STATION ACQUISITION DATA											STATION TERMINATION DATA										
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
GUM S_B	11	14	5	0	11	46	9	-31	-3	94	5	85	-4	59313	0	23	0	14	-29	-5	-93	5	29	-84	101172
CAR SB	11	34	47	0	13	49	22	-30	-2	90	5	85	0	68157	1	1	24	10	-29	-6	-94	5	-85	-4	108486
MAD DS	10	9	38	0	22	28	8	-26	-7	104	5	70	75	99390	1	8	37	47	-26	-9	-106	5	73	-73	128678
ASC SB	11	24	10	0	22	35	25	-26	-6	95	5	85	-5	99781	1	9	59	35	-26	-8	-97	5	-85	-7	132199
CYI SB	10	38	26	0	23	1	21	-26	-7	101	5	85	-11	101153	1	9	39	46	-26	-8	-97	5	-85	-7	132199
ANT SB	10	54	12	1	2	1	26	-25	-7	99	5	85	-9	110335	1	12	55	37	-25	-9	-101	5	-85	-11	139498
BDA SB	10	25	51	1	2	26	33	-25	-8	103	5	85	-13	111569	1	12	52	23	-25	-9	-101	5	-85	-11	139498
GBI SB	10	37	9	1	3	16	16	-25	-8	101	5	85	-11	113982	1	13	53	25	-25	-9	-103	5	-85	-13	141820
MLA SB	10	33	15	1	3	28	5	-25	-8	102	5	85	-12	114548	1	14	1	20	-25	-9	-103	5	-85	-13	142135
TEX SB	10	34	12	1	4	35	16	-24	-8	102	5	85	-12	117732	1	15	9	28	-25	-9	-103	5	-85	-13	144823
GYM SB	10	32	57	1	5	29	54	-24	-8	102	5	85	-12	120270	1	16	2	50	-25	-9	-103	5	-85	-13	146896
GLD DS	10	15	36	1	6	3	6	-24	-8	104	5	70	75	121791	1	16	18	43	-25	-10	-105	5	72	-74	147507
HAW SB	10	42	25	1	8	43	21	-24	-8	101	5	85	-11	128921	1	19	25	46	-24	-10	-102	5	-85	-12	154533
CNB DS	11	53	45	1	11	37	42	-23	-7	95	5	48	83	136312	1	23	31	26	-23	-9	-97	5	55	-81	163307
GUM SB	10	55	50	1	12	21	25	-23	-9	100	5	85	-10	138108	1	23	17	16	-23	-9	-97	5	55	-81	163307
CAR SB	11	43	0	1	14	4	24	-23	-8	96	5	85	-6	142260	2	1	47	24	-23	-9	-98	5	-85	-8	167959
ASC SB	11	24	15	1	22	48	20	-21	-9	99	5	85	-9	161802	2	10	12	35	-22	-10	-99	5	-85	-9	184212
MAD DS	9	49	50	1	22	53	31	-22	-10	108	5	74	71	161980	2	8	43	21	-22	-10	-99	5	-85	-9	184212
CYI SB	10	25	18	1	23	22	12	-21	-10	104	5	85	-14	162983	2	9	47	30	-22	-10	-99	5	-85	-9	184212
ANT SB	10	46	22	2	2	17	13	-21	-10	102	5	85	-12	168960	2	13	3	36	-22	-11	-103	5	-85	-13	189448
BDA SB	10	11	43	2	2	45	34	-21	-10	106	5	85	-15	169906	2	12	57	16	-22	-11	-103	5	-85	-13	189448
GBI SB	10	25	34	2	3	33	18	-21	-10	104	5	85	-14	171489	2	13	58	52	-22	-11	-105	5	-85	-15	191047
MLA SB	10	21	25	2	3	45	19	-21	-10	105	5	85	-15	171886	2	14	6	44	-22	-11	-105	5	-85	-15	191318
TEX SB	10	22	34	2	4	51	33	-21	-10	104	5	85	-14	174073	2	15	14	7	-22	-11	-105	5	-85	-15	193289
GYM SB	10	21	44	2	5	45	38	-21	-10	105	5	85	-15	175800	2	16	7	21	-22	-11	-105	5	-85	-15	194903

TABLE VI.- MISSION RADAR TIMELINE - Continued

(c) 5° minimum elevation - Continued

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA										STATION TERMINATION DATA									
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
GLD DS	10	1	28	2	6	20	12	-21	-11	107	5	73	73	176908	2	16	21	40	-21	-11	-108	5	74	-72	195331
HAW SB	10	32	26	2	8	56	17	-20	-11	104	5	85	-13	181863	2	19	28	43	-22	-11	-105	5	-85	-14	200955
CNB DS	9	17	41	2	11	39	17	-20	-10	98	5	59	80	186877	2	20	56	57	-21	-11	-75	38	-19	-49	201923
GUM SB	8	26	2	2	12	31	1	-20	-11	102	5	85	-12	188400	2	20	57	3	-22	-12	-117	38	-49	-21	201949
CAR SB	6	49	18	2	14	7	36	-20	-10	99	5	85	-9	191343	2	20	56	54	-22	-12	-117	38	-49	-21	201949
				LOI IGNITION				2 day 21 hr 7 min 29 sec																	
				LOI CUTOFF				2 day 21 hr 11 min 35 sec																	
CAR SB	1	24	47	2	21	30	18	-21	-11	+63	64	+24	12	200563	2	22	55	5	-20	-11	-79	46	-43	8	201435
CNB DS	1	24	47	2	21	30	19	-22	-11	-81	31	+15	-57	201843	2	22	55	6	-21	-10	-92	15	9	-75	203032
GUM SB	1	24	43	2	21	30	31	-22	-12	-112	30	+58	-19	201914	2	22	55	13	-21	-11	-105	12	-78	-14	203220
ASC SB	0	1	34	2	22	53	3	-19	-11	100	5	85	-10	203510	2	22	54	37	-21	-11	-105	12	-78	-14	203220
ASC SB	1	24	40	2	23	38	19	-19	-11	99	16	74	-9	202994	3	1	2	59	-18	-10	97	36	54	-6	202181
CYI SB	1	24	38	2	23	38	27	-19	-11	107	7	83	-17	203544	3	1	3	5	-18	-11	117	24	64	-25	202826
MAD DS	1	24	38	2	23	38	33	-19	-12	116	11	66	62	203281	3	1	3	11	-18	-11	131	24	56	43	202789
CNB DS	0	4	10	2	23	38	44	-21	-10	-99	6	56	-80	203585	2	23	42	54	-18	-11	131	24	56	43	202789
CAR SB	1	24	41	2	23	38	44	-21	-11	-85	36	-54	4	201911	3	1	3	26	-20	-10	-93	18	-72	-3	203175
				CIRCULARIZATION BURN IGNITION											3 day 1 hr 30 min 53 sec										
				CIRCULARIZATION BURN CUTOFF											3 day 1 hr 31 min 3 sec										
ASC SB	1	11	31	3	1	47	52	-18	-10	97	47	43	-5	201684	3	2	59	23	-17	-10	96	64	26	-3	201278
CYI SB	1	11	29	3	1	47	60	-18	-11	126	32	52	-30	202366	3	2	59	29	-17	-10	141	43	33	-35	201996
MAD DS	1	11	30	3	1	48	3	-18	-11	142	30	54	32	202461	3	2	59	33	-18	-11	161	37	51	15	202296
CAR SB	0	10	54	3	1	48	12	-20	-10	+98	7	+83	-8	203738	3	1	59	6	-18	-11	161	37	51	15	202296
ANT SB	0	30	59	3	2	28	15	-17	-10	102	5	85	-12	202699	3	2	59	15	-18	-11	161	37	51	15	202296
BDA SB	0	1	22	3	2	57	59	-17	-10	106	5	85	-16	203979	3	2	59	21	-18	-11	161	37	51	15	202296
GBI SB	1	11	51	3	3	45	55	-17	-10	104	5	85	-14	204170	3	4	57	46	-16	-10	113	20	69	-21	203473
ANT SB	1	11	50	3	3	45	55	-17	-10	109	23	66	-18	203158	3	4	57	45	-16	-10	113	20	69	-21	203473
BDA SB	1	11	52	3	3	45	57	-17	-10	113	15	74	-22	203611	3	4	57	49	-16	-10	124	28	58	-30	203050
ASC SB	1	11	52	3	3	46	1	-18	-10	99	76	14	-2	201168	3	4	57	53	-17	-9	-116	87	-3	-1	201240
CYI SB	1	11	50	3	3	46	8	-18	-10	156	49	19	-37	201899	3	4	57	58	-17	-10	-177	52	-2	-38	201944

TABLE VI.- MISSION RADAR TIMELINE - Continued

(c) 5° minimum elevation - Continued

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA										STATION TERMINATION DATA									
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
MAD DS	1	11	44	3	3	46	16	-18	-11	175	39	51	4	202324	3	4	57	60	-17	-10	-163	38	51	-13	202540
MLA SB	1	0	35	3	3	57	11	-17	-10	105	5	85	-15	203625	3	4	57	46	-17	-10	-163	38	51	-13	202540
TEX SB	1	11	30	3	5	44	26	-16	-10	109	13	76	-18	203962	3	6	55	57	-15	-9	119	27	59	-25	203333
GBI SB	1	11	34	3	5	44	28	-16	-10	120	29	57	-26	203072	3	6	56	2	-15	-9	134	42	39	-31	202628
MLA SB	1	11	30	3	5	44	29	-16	-10	119	27	60	-26	203221	3	6	55	58	-15	-9	134	42	39	-31	202628
ANT SB	1	11	32	3	5	44	30	-16	-10	127	48	36	-24	202225	3	6	56	2	-15	-9	148	59	18	-26	201979
BDA SB	1	11	32	3	5	44	32	-16	-10	135	35	45	-35	202764	3	6	56	4	-15	-9	153	44	25	-40	202521
ASC SB	1	11	34	3	5	44	40	-17	-9	-97	75	-15	-2	201445	3	6	56	14	-16	-9	-94	58	-32	2	202024
CYI SB	1	11	35	3	5	44	42	-17	-10	-159	50	-17	-37	202119	3	6	56	17	-16	-9	-137	42	-37	-33	202621
MAD DS	1	11	35	3	5	44	46	-17	-10	-149	34	52	-25	202805	3	6	56	21	-16	-10	-132	27	53	-42	203396
GYM SB	0	56	38	3	5	59	17	-16	-10	104	5	85	-14	203730	3	6	55	55	-16	-10	-132	27	53	-42	203396
GLD DS	0	21	20	3	6	34	34	-15	-10	105	5	72	74	203522	3	6	55	54	-16	-10	-132	27	53	-42	203396
GYM SB	1	11	46	3	7	42	31	-15	-9	118	26	61	-25	203546	3	8	54	17	-14	-9	131	39	43	-31	203052
TEX SB	1	11	51	3	7	42	31	-15	-9	128	36	47	-30	203026	3	8	54	22	-14	-9	145	47	28	-34	202697
GLD DS	1	11	46	3	7	42	32	-15	-10	116	18	54	59	203991	3	8	54	18	-14	-9	145	47	28	-34	202697
GBI SB	1	11	47	3	7	42	39	-15	-9	148	49	25	-34	202474	3	8	54	26	-15	-9	174	54	5	-35	202431
ANT SB	1	11	47	3	7	42	42	-16	-9	171	63	5	-26	201985	3	8	54	29	-15	-9	-152	61	-14	-25	202217
MLA SB	1	11	42	3	7	42	43	-15	-9	146	46	29	-35	202583	3	8	54	25	-15	-9	-152	61	-14	-25	202217
BDA SB	1	11	43	3	7	42	48	-16	-10	170	48	9	-42	202506	3	8	54	31	-15	-9	-165	48	-13	-41	202685
ASC SB	1	11	44	3	7	42	52	-16	-9	-95	46	-43	-3	202553	3	8	54	35	-16	-8	-95	30	-60	44	203529
CYI SB	1	11	38	3	7	42	58	-16	-9	-126	34	-50	-29	203088	3	8	54	36	-15	-9	-113	22	-67	-22	203950
MAD DS	1	11	39	3	7	43	0	-16	-10	-122	19	57	-53	203885	3	8	54	39	-15	-9	-109	8	67	-69	204734
HAW SB	1	11	31	3	9	40	55	-14	-9	104	11	79	-14	204661	3	10	52	26	-13	-8	112	26	62	-20	203955
GYM SB	1	11	34	3	9	41	4	-14	-9	143	46	30	-34	202848	3	10	52	37	-14	-8	167	53	9	-36	202752
GLD DS	1	11	34	3	9	41	4	-14	-9	141	37	46	31	203252	3	10	52	39	-14	-8	161	44	44	14	203090

TABLE VI.- MISSION RADAR TIMELINE - Continued

(c) 5° minimum elevation - Continued

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA											STATION TERMINATION DATA										
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
TEX SB	1	11	40	3	9	41	6	-15	-9	162	52	14	-36	202619	3	10	52	46	-14	-8	-170	53	-7	-36	202738
MLA SB	1	11	37	3	9	41	11	-15	-9	-171	52	-7	-37	202605	3	10	52	47	-14	-8	-146	47	-28	-34	202986
GBI SB	1	11	36	3	9	41	13	-15	-9	-166	54	-10	-35	202553	3	10	52	49	-14	-8	-141	47	-30	-32	202979
ANT SB	1	11	39	3	9	41	14	-15	-9	-134	54	-27	-24	202528	3	10	52	52	-14	-8	-118	41	-45	-21	203235
BDA SB	1	11	40	3	9	41	14	-15	-9	-149	44	-28	-38	202941	3	10	52	53	-14	-8	-131	35	-48	-32	203542
ASC SB	0	55	18	3	9	41	15	-16	-8	+96	18	-72	-6	204251	3	10	36	34	-14	-8	-131	35	-48	-32	203542
CYI SB	0	33	59	3	9	41	21	-16	-9	-107	12	+78	-16	204596	3	10	15	20	-14	-8	-131	35	-48	-32	203542
HAW SB	1	11	42	3	11	39	8	-13	-8	119	36	50	-23	203585	3	12	50	50	-12	-8	134	49	32	-27	203169
GYM SB	1	11	38	3	11	39	24	-14	-8	-173	53	-5	-36	202846	3	12	51	3	-13	-8	-147	49	-26	-34	203207
GLD DS	1	11	36	3	11	39	25	-14	-9	177	46	44	2	203123	3	12	51	1	-13	-8	-147	49	-26	-34	203207
TEX SB	1	11	38	3	11	39	26	-14	-8	-152	50	-22	-35	202969	3	12	51	4	-13	-8	-131	41	-41	-30	203531
GBI SB	1	11	38	3	11	39	31	-14	-8	-129	40	+43	-29	203402	3	12	51	8	-13	-8	-115	27	-61	-22	204219
MLA SB	1	11	36	3	11	39	32	-14	-8	-132	40	-41	-31	203380	3	12	51	8	-13	-8	-118	28	-59	-24	204160
ANT SB	1	11	34	3	11	39	35	-15	-8	-111	31	-57	-18	203823	3	12	51	9	-14	-8	-103	16	-74	-13	204857
BDA SB	1	11	34	3	11	39	36	-14	-8	-121	27	-60	-27	204049	3	12	51	9	-14	-8	-109	14	-75	-18	204956
CNB DS	0	37	45	3	12	12	52	-13	-7	95	5	45	83	204069	3	12	50	37	-14	-8	-109	14	-75	-18	204956
CNB DS	1	11	36	3	13	37	18	-12	-7	83	22	+18	67	204617	3	14	48	54	-11	-6	71	35	-26	51	204071
GUM SB	1	11	31	3	13	37	25	-12	-8	102	15	75	-11	204991	3	14	48	56	-11	-7	107	31	58	-14	204254
HAW SB	1	11	41	3	13	37	35	-13	-8	150	56	18	-29	203034	3	14	49	16	-12	-7	-178	61	-1	-29	203067
GLD DS	1	11	45	3	13	37	44	-13	-8	-144	40	44	-27	203677	3	14	49	30	-12	-7	-127	30	46	-44	204328
GYM SB	1	11	44	3	13	37	46	-13	-8	-133	42	-39	-31	203584	3	14	49	30	-12	-7	-118	30	-57	-24	204355
TEX SB	1	11	47	3	13	37	47	-13	-8	-121	32	-54	-26	204027	3	14	49	34	-13	-7	-109	19	-70	-18	204944
MLA SB	1	9	31	3	13	37	49	-14	-8	-110	19	-70	-19	204765	3	14	47	19	-13	-7	-109	19	-70	-18	204944
GBI SB	1	1	1	3	13	37	49	-14	-8	-108	17	-72	-18	204847	3	14	38	50	-13	-7	-109	19	-70	-18	204944
CAR SB	0	3	15	3	14	45	33	-11	-6	95	5	85	-5	205550	3	14	48	48	-13	-7	-109	19	-70	-18	204944

TABLE VI.- MISSION RADAR TIMELINE - Continued

(c) 5° minimum elevation - Continued

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA										STATION TERMINATION DATA									
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
CAR SB	1	11	33	3	15	35	32	-11	-7	90	16	74	0	205201	3	16	47	4	-10	-6	81	32	58	7	204513
CNB DS	1	11	34	3	15	35	37	-11	-6	60	44	27	39	203802	3	16	47	11	-11	-6	40	54	-29	22	203546
GUM SB	1	11	33	3	15	35	44	-11	-7	113	42	46	-17	203866	3	16	47	17	-10	-7	126	57	28	-18	203499
HAW SB	1	11	30	3	15	36	0	-12	-7	-155	58	-15	-29	203248	3	16	47	31	-11	-7	-131	49	-33	-26	203753
GLD DS	1	11	27	3	15	36	10	-13	-7	-117	22	49	-55	204851	3	16	47	37	-12	-7	-106	10	58	-72	205764
TEX SB	0	19	5	3	15	36	10	-13	-7	-103	9	-81	-13	205605	3	15	55	16	-12	-7	-106	10	58	-72	205764
GYM SB	1	11	26	3	15	36	12	-13	-7	-110	20	-69	-19	204952	3	16	47	37	-12	-7	-101	6	-84	-11	205969
				TEI IGNITION 3 day 17 hr 4 min 2 sec																					
				TEI CUTOFF 3 day 17 hr 6 min 53 sec																					
CAR SB	8	57	27	3	17	21	14	-10	-6	77	39	50	10	204890	4	2	18	41	-12	-6	-94	5	-85	-4	196349
CNB DS	6	40	4	3	17	21	18	-11	-6	26	58	-29	13	204166	4	0	1	22	-12	-6	-94	5	-85	-4	196349
GUM SB	6	36	0	3	17	21	24	-11	-7	138	63	19	-19	204009	3	23	57	24	-12	-6	-94	5	-85	-4	196349
HAW SB	2	48	1	3	17	21	35	-12	-7	-123	42	-43	-24	204764	3	20	9	36	-12	-6	-94	5	-85	-4	196349
MAD DS	10	11	52	3	23	19	16	-11	-7	104	5	70	75	199832	4	9	31	9	-11	-7	-104	5	70	-75	187489
ASC SB	11	19	42	3	23	25	26	-10	-7	96	5	85	-6	199715	4	10	45	8	-12	-6	-96	5	-85	-6	185883
CYI SB	10	38	41	3	23	51	40	-10	-7	101	5	85	-11	199208	4	10	30	21	-12	-6	-96	5	-85	-6	185883
ANT SB	10	54	60	4	2	48	24	-10	-7	99	5	85	-9	195761	4	13	43	24	-11	-6	-98	5	-85	-8	181883
BDA SB	10	31	28	4	3	11	57	-10	-7	102	5	85	-12	195303	4	13	43	25	-11	-7	-101	5	-85	-11	181882
GBI SB	10	41	31	4	4	1	28	-10	-7	100	5	85	-10	194304	4	14	42	58	-11	-7	-100	5	-85	-10	180505
MLA SB	10	38	45	4	4	12	33	-10	-7	101	5	85	-11	194097	4	14	51	18	-11	-7	-100	5	-85	-10	180310
TEX SB	10	40	11	4	5	18	55	-10	-7	101	5	85	-11	192743	4	15	59	7	-11	-7	-100	5	-85	-10	178711
GYM SB	10	40	8	4	6	12	26	-10	-7	101	5	85	-11	191664	4	16	52	33	-11	-7	-100	5	-85	-10	177431
GLD DS	10	26	32	4	6	44	4	-10	-7	102	5	68	77	191014	4	17	10	36	-11	-7	-102	5	67	-77	176995
HAW SB	10	49	51	4	9	24	1	-10	-7	99	5	85	-9	187643	4	20	13	52	-11	-6	-99	5	-85	-9	172441
CNB DS	11	36	52	4	12	25	28	-9	-6	93	5	34	84	183656	5	0	2	19	-10	-5	-92	5	26	-84	166438
GUM SB	11	1	24	4	13	1	30	-9	-6	98	5	85	-8	182840	5	0	2	54	-10	-6	-97	5	-85	-7	166421
CAR SB	11	30	46	4	14	50	33	-9	-6	94	5	85	-4	180330	5	2	21	19	-10	-5	-93	5	-85	-3	162594

TABLE VI.- MISSION RADAR TIMELINE - Continued

(c) 5° minimum elevation - Continued

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA											STATION TERMINATION DATA										
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
MAD DS	10	21	53	4	23	21	19	-8	-6	103	5	68	76	167541	5	9	43	12	-9	-6	-102	5	67	-77	149311
ASC SB	11	20	3	4	23	31	43	-8	-5	95	5	85	-5	167264	5	10	51	46	-9	-5	-94	5	-85	-4	147094
CYI SB	10	45	45	4	23	55	12	-8	-6	100	5	85	-10	166629	5	10	40	56	-9	-5	-94	5	-85	-4	147094
ANT SB	11	0	10	5	2	53	34	-7	-6	98	5	85	-8	161679	5	13	53	45	-8	-5	-97	5	-85	-7	140979
BDA SB	10	39	54	5	3	15	55	-8	-6	100	5	85	-10	161041	5	13	55	49	-8	-5	-99	5	-85	-9	140907
GBI SB	10	48	56	5	4	6	1	-7	-6	99	5	85	-9	159596	5	14	54	56	-8	-5	-98	5	-85	-8	138844
MLA SB	10	46	21	5	4	17	16	-7	-6	99	5	85	-9	159269	5	15	3	37	-8	-5	-99	5	-85	-9	138538
TEX SB	10	48	3	5	5	23	45	-7	-6	99	5	85	-9	157313	5	16	11	48	-8	-5	-98	5	-85	-8	136105
GYM SB	10	48	1	5	6	17	38	-7	-6	99	5	85	-9	155701	5	17	5	39	-7	-5	-98	5	-85	-8	134146
GLD DS	10	36	30	5	6	48	32	-7	-6	101	5	65	78	154764	5	17	25	2	-7	-5	-100	5	63	-79	133433
HAW SB	10	56	47	5	9	30	49	-6	-5	98	5	85	-8	149708	5	20	27	36	-7	-4	-97	5	-85	-7	126487
CNB DS	11	27	2	5	12	40	38	-6	-4	91	5	13	85	143477	6	0	7	40	-6	-2	-89	5	-7	-85	117524
GUM SB	11	6	48	5	13	10	27	-6	-5	96	5	85	-6	142465	6	0	17	15	-6	-4	-95	5	-85	-5	117116
CAR SB	11	24	52	5	15	5	7	-5	-4	92	5	85	-2	138487	6	2	29	59	-5	-2	-90	5	-85	0	111339
MAD DS	10	43	2	5	23	29	51	-3	-5	100	5	64	79	119112	6	10	12	53	-3	-3	-98	5	59	-80	88596
ASC SB	11	21	8	5	23	48	46	-3	-3	93	5	85	-3	118321	6	11	9	54	-3	-1	-90	5	-85	0	85454
CYI SB	11	1	20	6	0	6	38	-3	-4	97	5	85	-7	117566	6	11	7	59	-3	-1	-90	5	-85	0	85454
ANT SB	11	14	11	6	3	8	51	-2	-3	95	5	85	-5	109591	6	14	23	2	-1	-1	-93	5	-85	-3	74081
BDA SB	11	1	51	6	3	28	26	-2	-4	98	5	85	-8	108700	6	14	30	17	-1	-2	-95	5	-85	-5	73630
GBI SB	11	9	19	6	4	20	18	-2	-4	97	5	85	-7	106309	6	15	29	37	0	-1	-94	5	-85	-4	69858
MLA SB	11	8	2	6	4	31	19	-2	-4	97	5	85	-7	105795	6	15	39	21	0	-1	-94	5	-85	-4	69226
TEX SB	11	11	28	6	5	38	49	-1	-3	96	5	85	-6	102593	6	16	50	17	1	-1	-94	5	-86	-4	64492
GYM SB	11	13	44	6	6	33	24	-1	-3	96	5	85	-6	99938	6	17	47	9	2	0	-93	5	-85	-3	60524
GLD DS	11	8	19	6	7	2	53	-1	-3	98	5	57	81	98477	6	18	11	12	2	-1	-94	5	41	-83	58793
HAW SB	11	32	45	6	9	51	21	1	-2	95	5	85	-5	89761	6	21	24	6	6	2	-90	5	-85	0	43927

TABLE VI.- MISSION RADAR TIMELINE - Concluded

(c) 5° minimum elevation - Concluded

VEHICLE	RADAR TABLE TRACKING TIME			STATION ACQUISITION DATA											STATION TERMINATION DATA										
	HRS	MIN	SEC	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE	DAY	HRS	MIN	SEC	RA	DEC	AZ	ELV	X	Y	RANGE
CNB DS	11	9	21	6	13	25	14	3	1	85	5	+42	83	77613	7	0	34	35	14	14	-69	5	-76	-68	24467
GUM SB	13	23	26	6	13	39	19	4	-1	92	5	85	-2	76764	7	3	2	44	-149	27	64	5	84	26	1038
CAR SB	10	52	58	6	15	52	49	5	1	86	5	85	4	68345	7	2	45	47	-149	27	64	5	84	26	1038
TAN TM	2	7	20	7	0	28	20	24	12	55	40	45	26	23400	7	2	35	40	-149	27	64	5	84	26	1038
CAR CB	2	17	15	7	0	28	32	16	13	-46	39	-42	33	23400	7	2	45	47	-149	27	64	5	84	26	1038
PRE CB	1	40	34	7	0	36	21	27	13	63	20	68	25	23400	7	2	16	55	-149	27	64	5	84	26	1038

ENTRY INTERFACE 7 day 3 hr 5 min 32 sec

TABLE VII.- MISSION SHADOW TIMELINE

(a) Earth orbit phase

[Insertion occurs at 0:00:11:20]

Lighting	Enter, g.e.t., day:hr:min:sec	Exit, g.e.t., day:hr:min:sec
Earth penumbra	0:00:51:33.8	0:00:51:46.1
Earth umbra	0:00:51:46.1	0:01:25:32.3
Earth penumbra	0:01:25:32.3	0:01:25:45.0
Sunlight	0:01:25:45.0	0:02:19:42.4
Earth penumbra	0:02:19:42.4	0:02:19:54.5
Earth umbra	0:02:19:54.5	--

(b) Translunar phase

[TLI ignition occurs at 0:02:50:31;
TLI cutoff occurs at 0:02:55:43]

Vehicle is in sunlight throughout translunar phase.

TABLE VII.- MISSION SHADOW TIMELINE - Continued

(c) Lunar orbit phase; LOI to circularization burn

[LOI ignition occurs at 2:21:07:29; cutoff at 2:21:11:35; circularization burn ignition occurs at 3:01:30; cutoff at 3:01:31:02]

Lighting	Enter, g.e.t., day:hr:min:sec	Exit, g.e.t., day:hr:min:sec
Lunar penumbra	2:22:13:59.3	2:22:14:12.7
Lunar umbra	2:22:14:12.7	2:23:00:13.9
Lunar penumbra	2:23:00:13.9	2:23:00:26.9
Sunlight	2:23:00:26.9	3:00:22:31.4
Lunar penumbra	3:00:22:31.4	3:00:22:46.7
Lunar umbra	3:00:22:46.7	3:01:08:46.3
Lunar penumbra	3:01:08:46.3	3:01:08:59.3
Sunlight	3:01:08:59.3	--

TABLE VII.- MISSION SHADOW TIMELINE - Continued

(d) Lunar orbit phase; circularization burn to TEI

[Circularization burn ignition occurs at 3:01:30:53; cutoff at 3:01:31:03]

Lighting	Enter, g.e.t., day:hr:min:sec	Exit, g.e.t., day:hr:min:sec
Lunar penumbra	3:02:22:45.0	3:02:22:56.1
Lunar umbra	3:02:22:56.1	3:03:08:53.4
Lunar penumbra	3:03:08:53.4	3:03:08:56.9
Sunlight	3:03:08:56.9	3:04:21:18.1
Lunar penumbra	3:04:21:18.1	3:04:21:29.3
Lunar umbra	3:04:21:29.3	3:05:07:25.4
Lunar penumbra	3:05:07:25.4	3:05:07:36.4
Sunlight	3:05:07:36.4	3:06:19:53.6
Lunar penumbra	3:06:19:53.6	3:06:20:02.3
Lunar umbra	3:06:20:02.3	3:07:05:59.0
Lunar penumbra	3:07:05:59.0	3:07:06:10.4
Sunlight	3:07:06:10.4	3:08:18:32.4
Lunar penumbra	3:08:18:32.4	3:08:18:43.8
Lunar umbra	3:08:18:43.8	3:09:04:38.7
Lunar penumbra	3:09:04:38.7	3:09:04:47.4
Sunlight	3:09:04:47.4	3:10:17:06.1
Lunar penumbra	3:10:17:06.1	3:10:17:17.0
Lunar umbra	3:10:17:17.0	3:11:03:13.3
Lunar penumbra	3:11:03:13.3	3:11:03:24.5

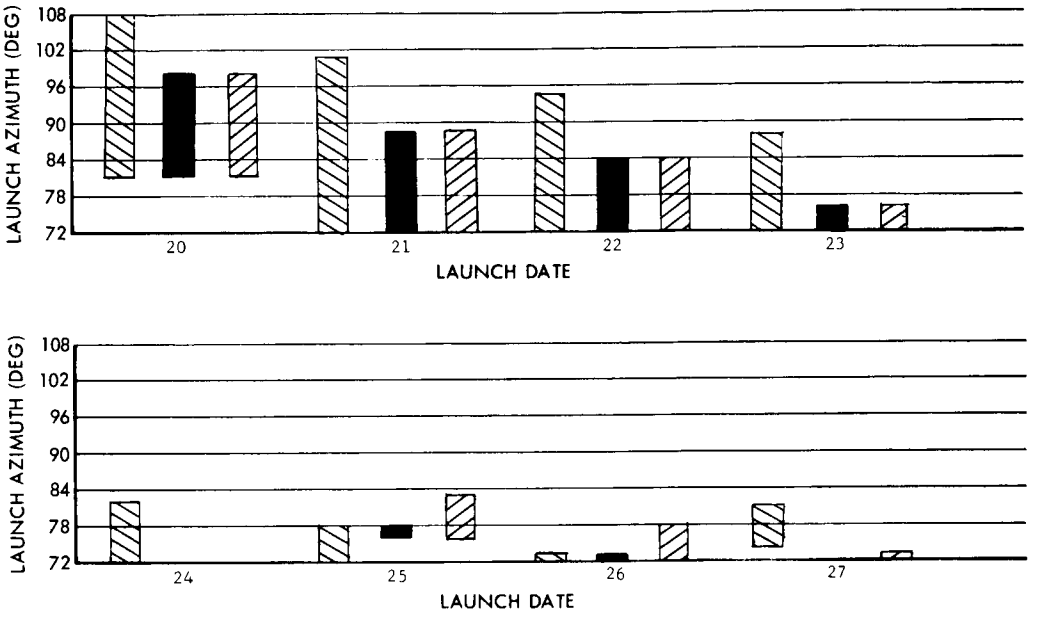
TABLE VII.- MISSION SHADOW TIMELINE - Concluded

(d) Lunar orbit phase; circularization burn to TEI - Concluded

Lighting	Enter, g.e.t., day:hr:min:sec	Exit, g.e.t., day:hr:min:sec
Sunlight	3:11:03:24.5	3:12:15:37.2
Lunar penumbra	3:12:15:37.2	3:12:15:51.4
Lunar umbra	3:12:15:51.4	3:13:01:46.5
Lunar penumbra	3:13:01:46.5	3:13:01:57.7
Sunlight	3:13:01:57.7	3:14:14:19.6
Lunar penumbra	3:14:14:19.6	3:14:14:30.9
Lunar umbra	3:14:14:30.9	3:15:00:25.9
Lunar penumbra	3:15:00:25.9	3:15:00:40.9
Sunlight	3:15:00:40.9	3:16:12:54.5
Lunar penumbra	3:16:12:54.5	3:16:13:05.2
Lunar umbra	3:16:13:05.2	3:16:59:00.8
Lunar penumbra	3:16:59:00.8	3:16:59:12.1
Sunlight	3:16:59:12.1	--
(e) Transearth phase		
[TEI ignition occurs at 3:17:04:02, cutoff at 3:17:06:53; entry interface occurs at 7:03:05:32]		
Earth penumbra	7:02:40:25.2	7:02:40:40.2
Earth umbra	7:02:40:40.2	--

TABLE VIII.- TRANSLUNAR INJECTION TRACKING SHIP COVERAGE

(a) Coverage and ship locations for the December 1968 launch window.



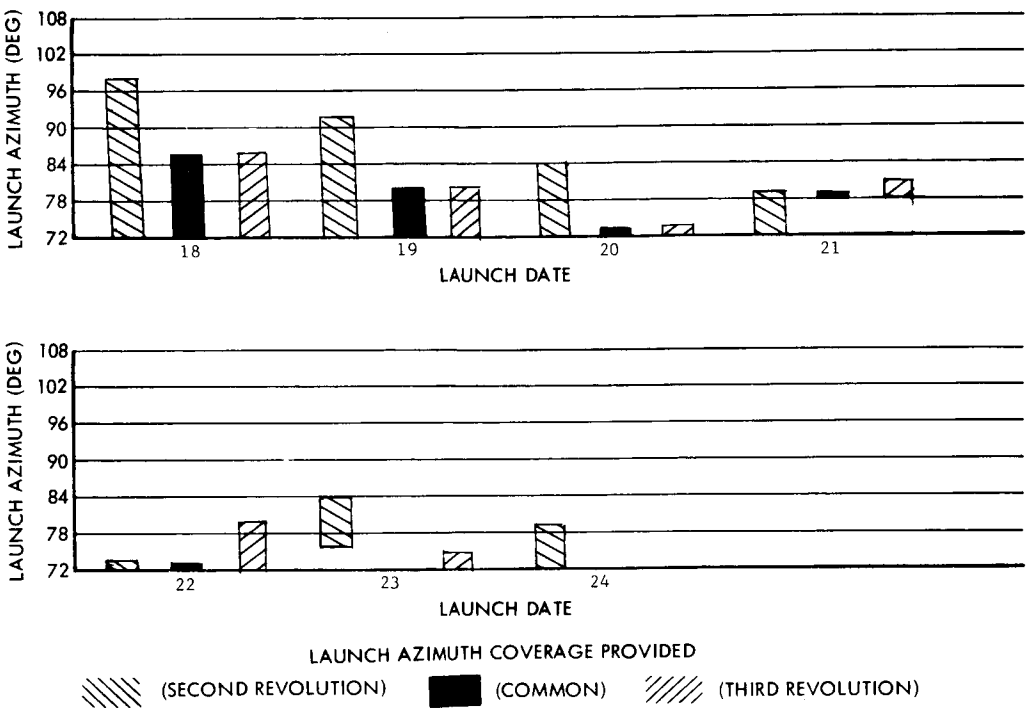
SHIP POSITIONS

Launch Date	Azimuths Covered (deg)			Launch Window Duration For Azimuths Covered (hr:min)			Ship Positions			
							Ship 1		Ship 2	
	Second Rev	Common	Third Rev	Second Rev	Common	Third Rev	Lat (deg)	Long (deg)	Lat (deg)	Long (deg)
20 Dec	81-108	81-98	81-98	3:55	2:06	2:06	11.0N	179.0E	7.0N	157.0E
21 Dec	72-101	72-89	72-89	3:45	2:00	2:00	7.5N	178.5W	2.5N	155.5E
22 Dec	72-95	72-84	72-84	3:00	1:27	1:27	2.0N	175.0E	2.5S	148.2E
23 Dec	72-88	72-76	72-76	2:07	0:36	0:36	0.0	171.0E	7.5S	148.0E
24 Dec	72-82	----	----	1:23	----	----	0.0	167.0E	11.0S	150.5E
25 Dec	72-78	76-78	76-83	0:52	0:19	1:04	1.0S	162.5E	13.0S	146.0E
26 Dec	72-73	72-73	72-78	0:10	0:10	1:00	3.0S	165.0E	17.5S	146.5E
27 Dec	74-81	----	72-73	1:18	----	0:10	3.0S	165.0E	17.5S	146.5E

NOTE: Tracking coverage from "TLI ignition - 2 minutes" through TLI ignition.

TABLE VIII.- TRANSLUNAR INJECTION TRACKING SHIP COVERAGE - Concluded

(b) Coverage and ship locations for the January 1969 launch window.



SHIP POSITIONS

Launch Date	Azimuths Covered (deg)			Launch Window Duration For Azimuths Covered (hr:min)			Ship Positions			
							Ship 1		Ship 2	
	Second Rev	Common	Third Rev	Second Rev	Common	Third Rev	Lat (deg)	Long (deg)	Lat (deg)	Long (deg)
18 Jan	72-98	72-86	72-86	3:26	1:34	1:34	4.0N	176.0E	1.0N	150.0E
19 Jan	72-92	72-80	72-80	2:38	0:57	0:57	1.0N	172.5E	3.5S	148.0E
20 Jan	72-84	72-73	72-73	1:37	0:07	0:07	1.0N	168.0E	10.7S	150.7E
21 Jan	72-79	78-79	78-81	1:00	0:09	0:27	2.5S	165.0E	10.7S	145.7E
22 Jan	72-73	72-73	72-80	0:10	0:10	1:17	5.5S	161.0E	11.0S	141.0E
23 Jan	76-84	----	72-75	1:28	----	0:42	8.5S	159.5E	14.5S	137.5E
24 Jan	72-79	----	----	1:26	----	----	8.5S	159.5E	16.0S	137.6E

NOTE: Tracking coverage from "TLI ignition - 2 minutes" through TLI ignition.

TABLE IX.- POST-TLI EVENTS TIMELINE

Time from TLI ignition,[a] sec	Time from TB_7, sec	Event	ΔV, fps	Comment
	0	Hold cutoff attitude		
		Initiate LH2 and LOX NPV's		
		Initiate LH2 continuous vent		Propulsive
	20	Command and hold local horizontal		
	150	LOX NPV turned off		
	900	LH2 NPV turned off		
		LH2 PV turned off		
		Initiate maneuver to separation attitude		
	1080	Freeze separation attitude inertially		
1800	1500	SC separation/SLA jettison	1	+X RCS
1805	1505	Coast to 50 ft separation distance		
1855	1555	Null .5 fps separation rate	.5	-X RCS
1858	1558	Pitch 180° (SC)		5 deg/sec
1894	1594	Null .5 fps separation rate	.5	+X RCS
1897	1597	Roll left 60° (SC)		5 deg/sec
1910	1610	Station keep, visual observation photography		Range ≈ 70 ft

[a]The SC maneuver times will be referenced to TLI ignition, the LV maneuvers to TB_7. The times of the SC maneuvers referenced to TB_7 (column 2) are approximate and based on a 300-second TLI burn time. These times will change as TLI burn time changes.

TABLE IX.- POST-TLI EVENTS TIMELINE - Concluded

Time from TLI ignition,[a] sec	Time from TB_7, sec	Event	ΔV, fps	Comment
2700	2400	Initiate evasive maneuver	1.5	Δt = attitude maneuver time + 8-sec RCS
	3600	LH2 NPV turned on		
	4500	LH2 NPV turned off		
	6540	Command LOX dump attitude		local horizontal retro
	7200	LH2 PV turned on		
	7920	Inititate LOX dump command	90 ± 18	Average dump time ≈ 240 sec
	8220	LOX dump command off		
	8223	LOX and LH2 NPV's turned on		LV safing

[a]The SC maneuver times will be referenced to TLI ignition, the LV maneuvers to TB_7. The times of the SC maneuvers referenced to TB_7 (column 2) are approximate and based on a 300-second TLI burn time. These times will change as TLI burn time changes.

TABLE X.- TARGET LOADS FOR LUNAR ORBIT INSERTION, CIRCULARIZATION, AND TRANSEARTH INJECTION

[Propulsion system - SPS; guidance - external ΔV]

REFSMMAT

$$\begin{bmatrix} -.64877632 & .076384120 & -.75713590 \\ -.66111865 & -.54928435 & .51108595 \\ -.37684405 & .83213712 & 0.40686164 \end{bmatrix}$$

Targets

Parameter	LOI	Circularization	TEI
T_{ig}, hr:min:sec, g.e.t.	69:07:29.17	73:30:52.80	89:04:01.86
ΔV_x, fps	-2977.2	-138.5	2836.9
ΔV_y, fps	+232.5	0	28.8
ΔV_z, fps	+166.8	0	67.1

Gimbal angles at T_{ig}

Angle	LOI	Circularization	TEI
IGA, deg	-161	-178	39
MGA, deg	+5	-2	3
OGA, deg	0	0	180

TABLE XI.- REFSMMAT AND GIMBAL ANGLES FOR REENTRY

REFSMMAT

$$\begin{bmatrix} .5310936 & .76132403 & .37192111 \\ -.016918018 & .44838224 & -.89368179 \\ -.84714425 & .46833652 & .25101303 \end{bmatrix}$$

Gimbal angles at entry interface

IGA, deg	-23.5
MGA, deg	-0.8
OGA, deg	-0.3

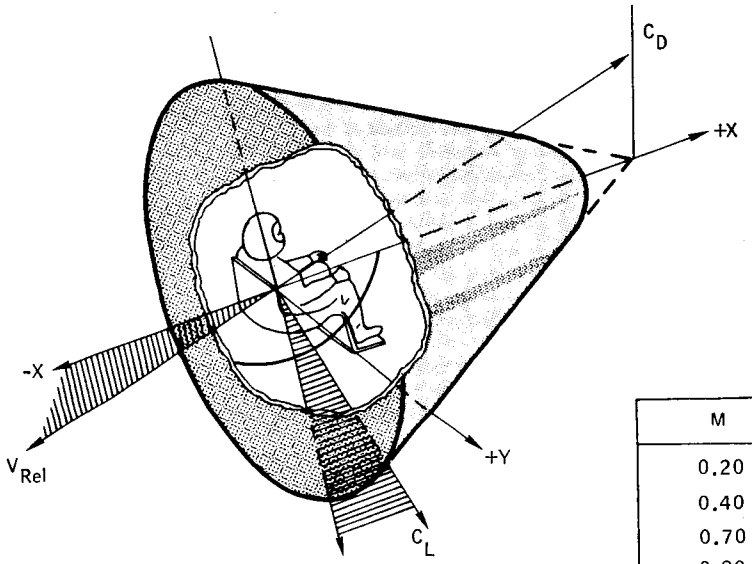
TABLE XII.- COMMAND MODULE MASS PROPERTIES

CM weight, lb	12 215.8
Centers of gravity in Apollo coordinate system, in	
X_A	1040.68
Y_A	-0.03
Z_A	5.91
Moments of inertia, slug-ft^2	
I_{XX}	5817
I_{YY}	4985
I_{ZZ}	4506
Products of inertia, slug-ft^2	
I_{XY}	46.6
I_{XZ}	-403.0
I_{YZ}	27.4

TABLE XIII.- CONDITIONS AT ENTRY INTERFACE

Elapsed time from launch, hr:min:sec	171:05:31.7
Inertial velocity, fps	36 070.88
Inertial flight-path angle, deg	-6.26
Inertial azimuth, deg	112.95
Spacecraft geodetic latitude, deg	14.629
Spacecraft longitude, deg	174.75
Target geodetic latitude, deg	4.3
Target longitude, deg	-165.
Altitude, ft	400 050.

TABLE XIV.- COMMAND MODULE AERODYNAMIC COEFFICIENTS



AERODYNAMIC COEFFICIENTS AT TRIM ANGLE OF ATTACK
AS A FUNCTION OF MACH NUMBER

M	α, deg	C_L	C_D	L/D
0.20	170.82	0.23583	0.82490	0.28588
0.40	167.38	0.23953	0.85388	0.28054
0.70	164.68	0.25991	0.98725	0.26327
0.90	161.99	0.31655	1.06761	0.29651
1.10	155.27	0.48743	1.17460	0.41498
1.20	155.47	0.47311	1.16020	0.40778
1.35	154.35	0.55663	1.28293	0.43388
1.65	153.54	0.54582	1.26977	0.42986
2.00	153.47	0.52946	1.27861	0.41409
2.40	153.99	0.50407	1.24808	0.40388
3.00	154.47	0.47569	1.22390	0.38867
4.00	156.42	0.43816	1.22038	0.35904
10.00	157.07	0.42539	1.23030	0.34576
29.50	160.36	0.38375	1.29478	0.29638

Center of gravity location in body coordinates

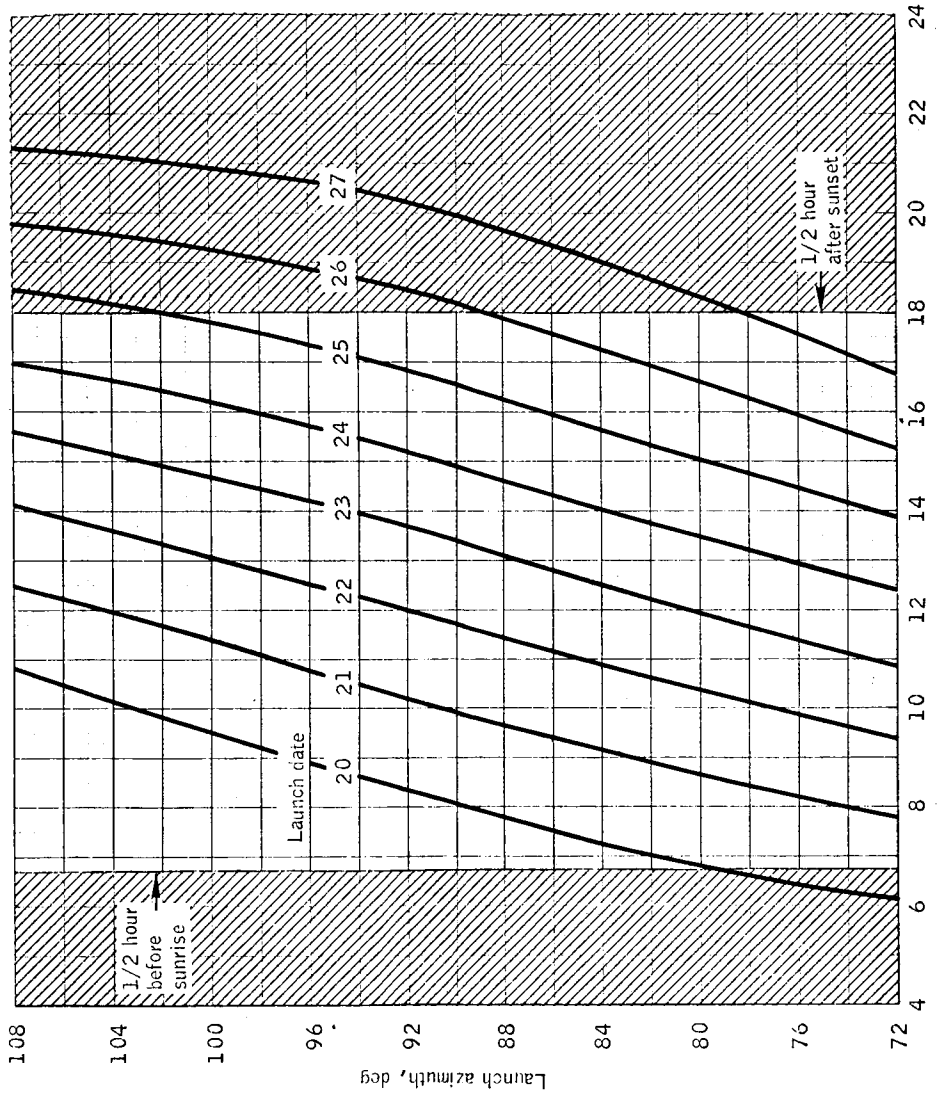
X_{cg} = 1040.68 in.

Y_{cg} = -0.03 in.

Z_{cg} = 5.91 in.

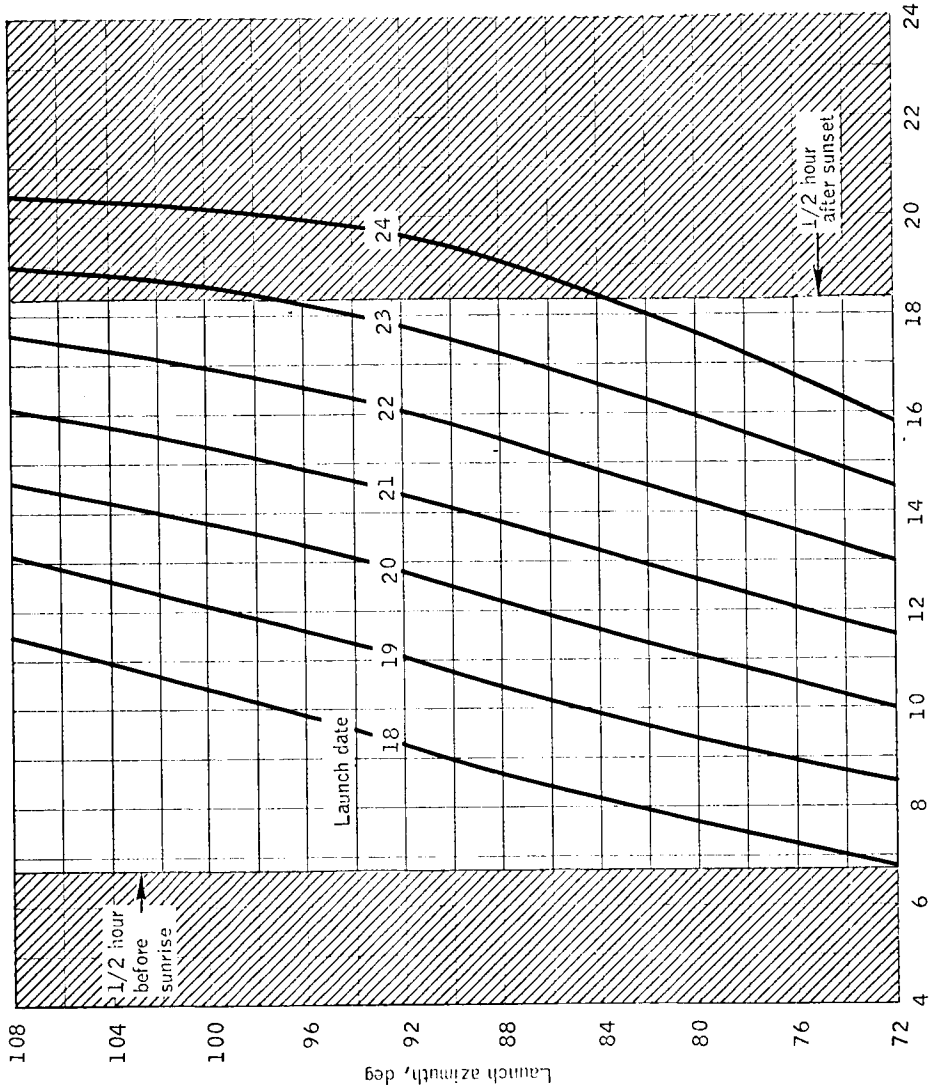
TABLE XV.- ENTRY EVENTS SEQUENCE

Event	Time from lift-off, hr:min:sec	Time from 400 000 ft, min:sec
Reentry	171:05:32	00:00
Enter S-band communication blackout	171:05:59	00:27
Enter C-band communication blackout Load factor = 0.05g	171:06:04	00:32
Maximum heating rate	171:06:42	01:10
Guidance initiate at R-DOT = -700 fps	171:06:52	01:20
Maximum load factor (FIRST)	171:06:58	01:26
Exit C-band communication blackout	171:08:36	03:04
Exit S-band communication blackout	171:09:00	03:28
Maximum load factor (SECOND)	171:11:20	05:48
Termination of CMC guidance	171:12:52	07:20
Drogues parachute deployment	171:13:55	08:23
Main parachutes deployment	171:14:48	09:16
Splashdown	171:19:18	13:46



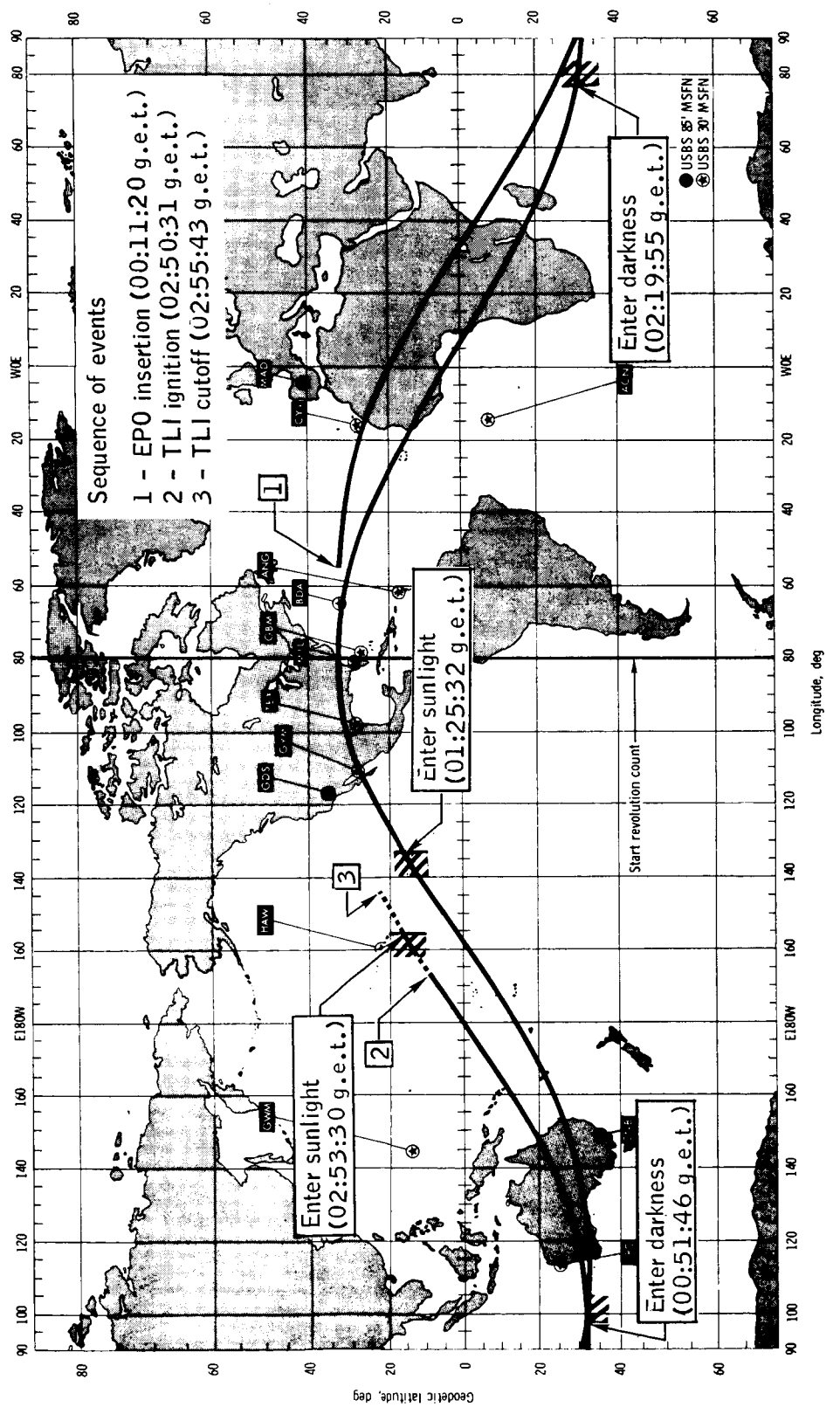
(a) December 1968 launch window.

Figure 1.- Lighting conditions at lift-off.



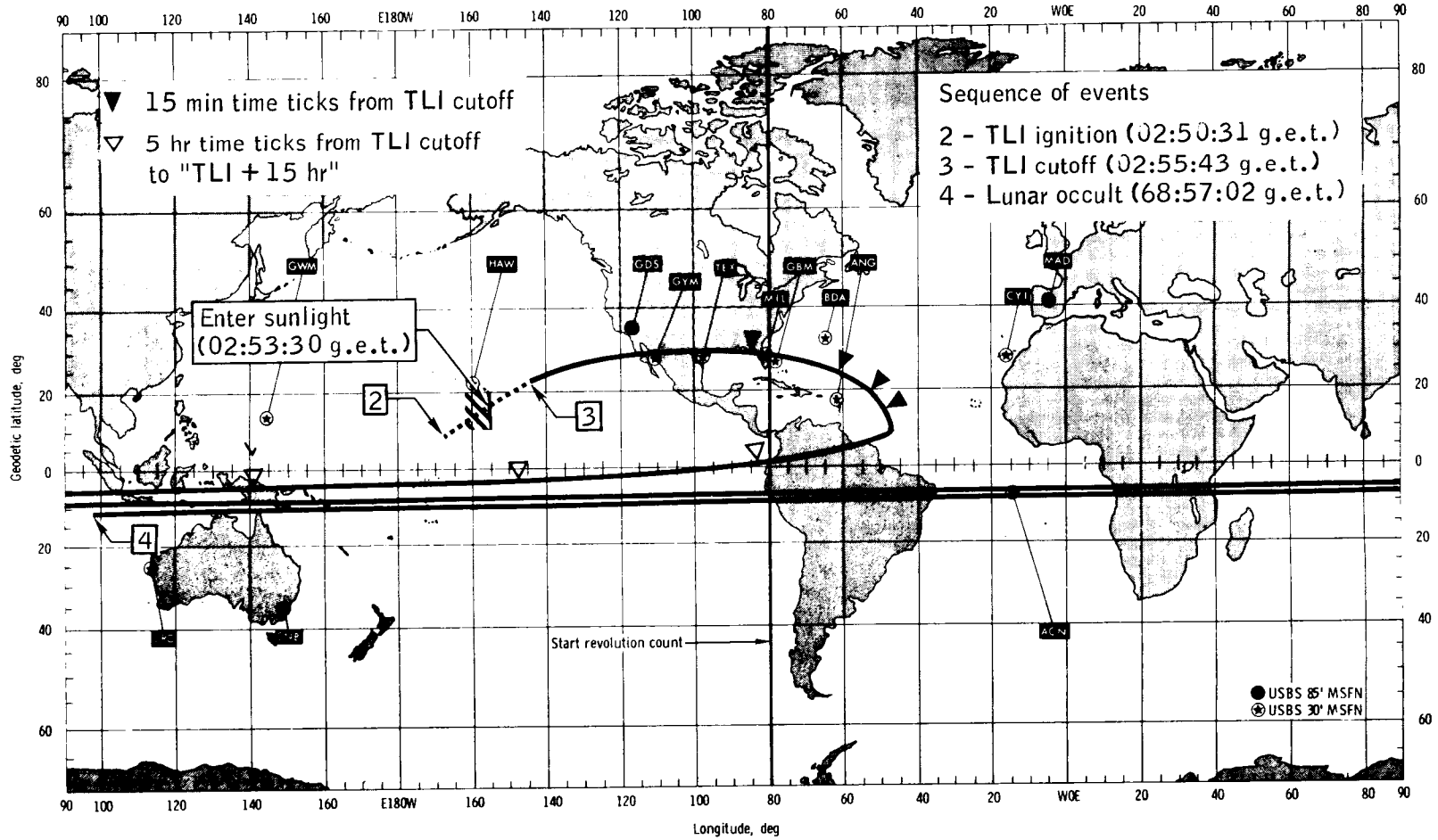
(b) January 1969 launch window.

Figure 1.- Concluded.



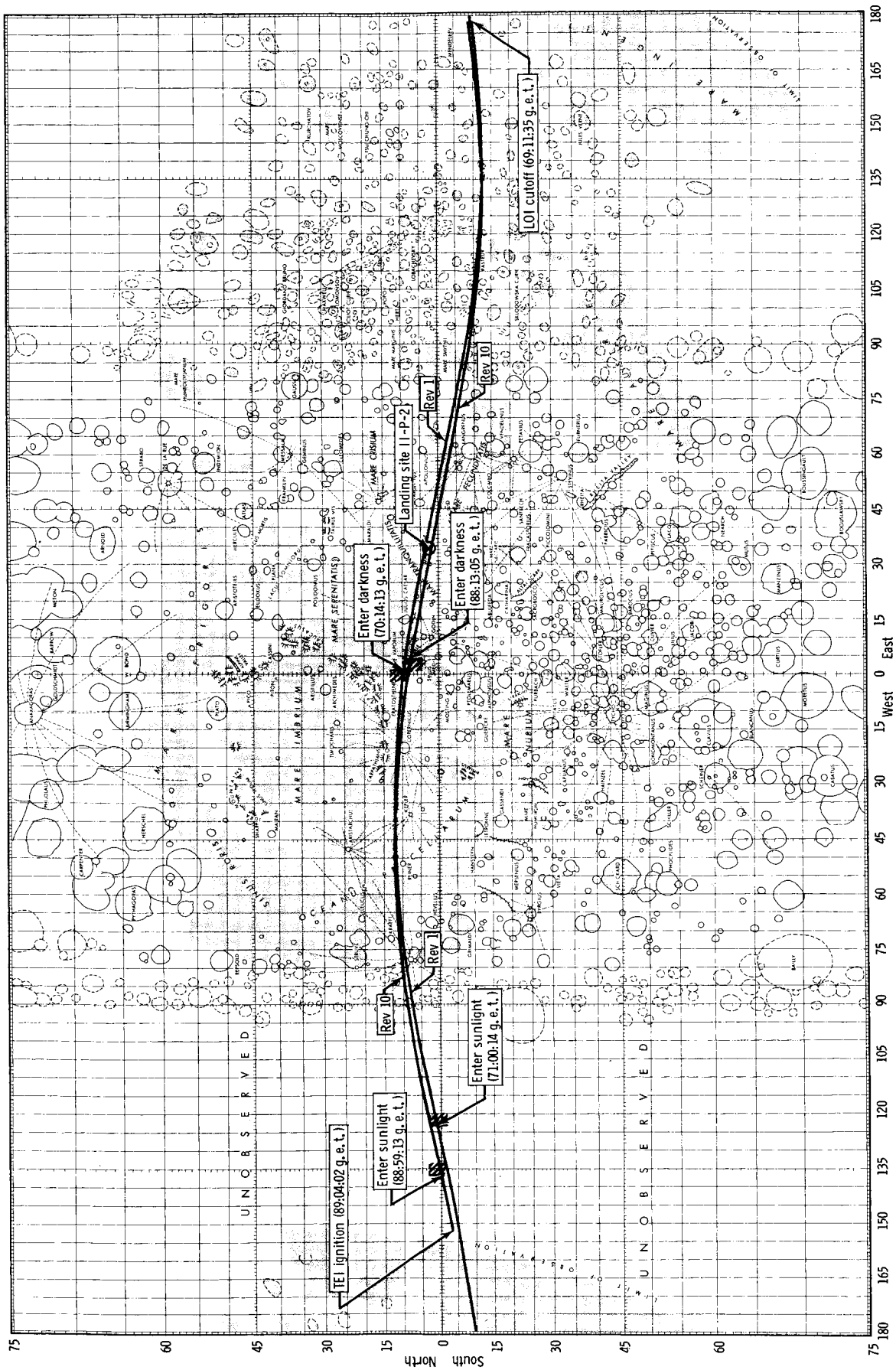
(a) Earth parking orbit.

Figure 2.- Mission ground tracks.



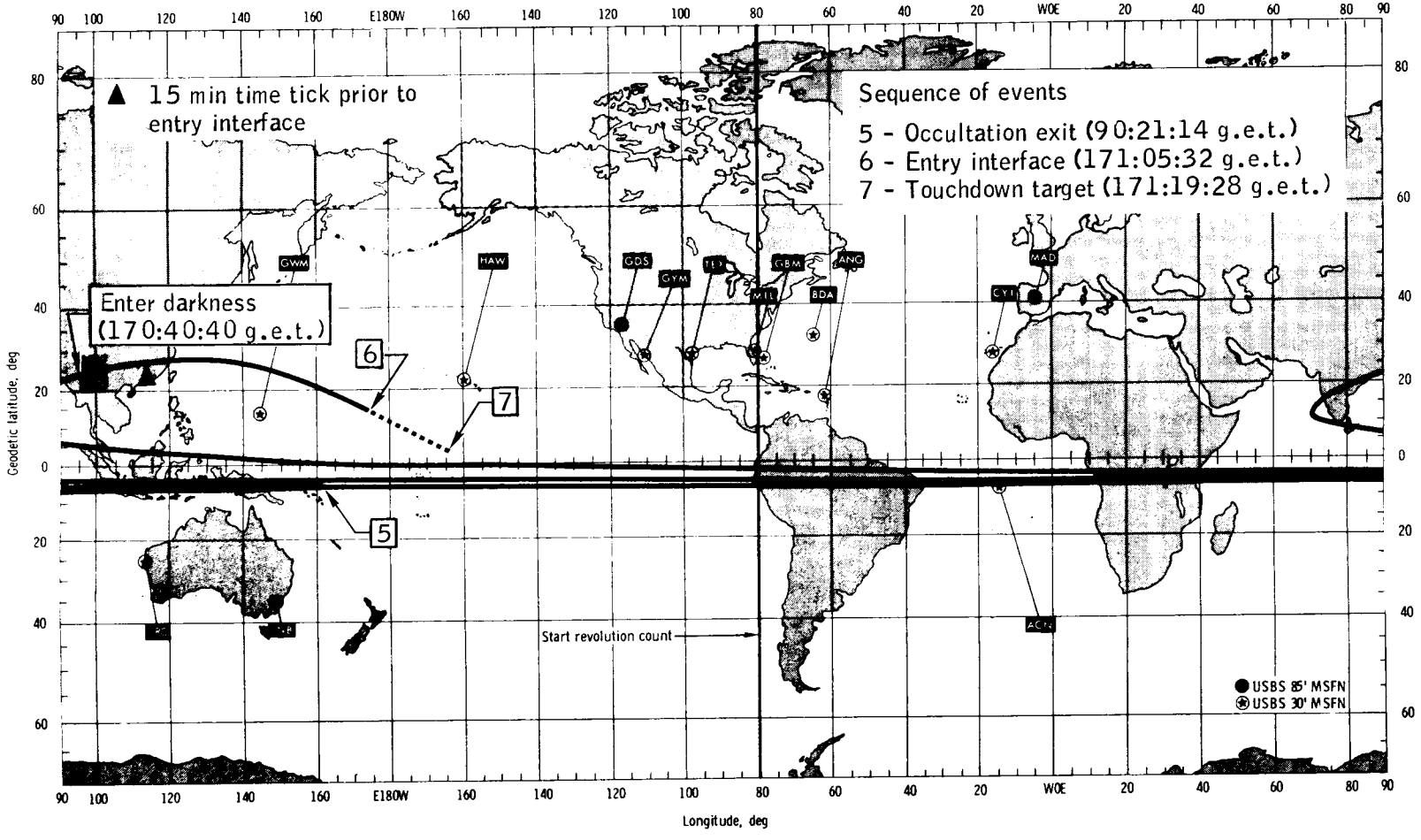
(b) Translunar coast.

Figure 2.- Continued.



(c) Lunar parking orbit.

Figure 2.- Continued.



(d) Transearth coast.

Figure 2.- Concluded.

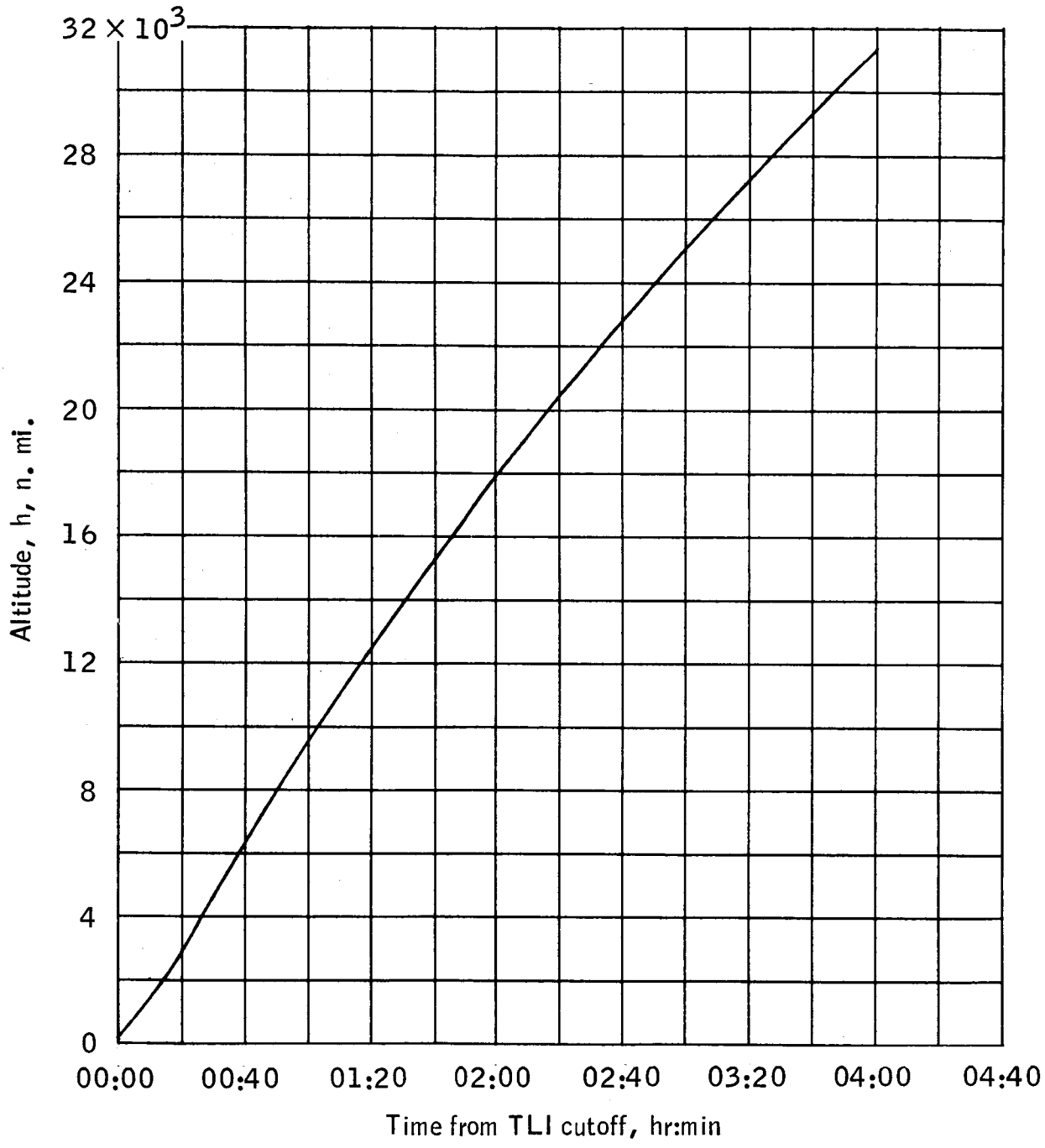


Figure 3.- Time history of altitude for first 4 hours of translunar coast phase.

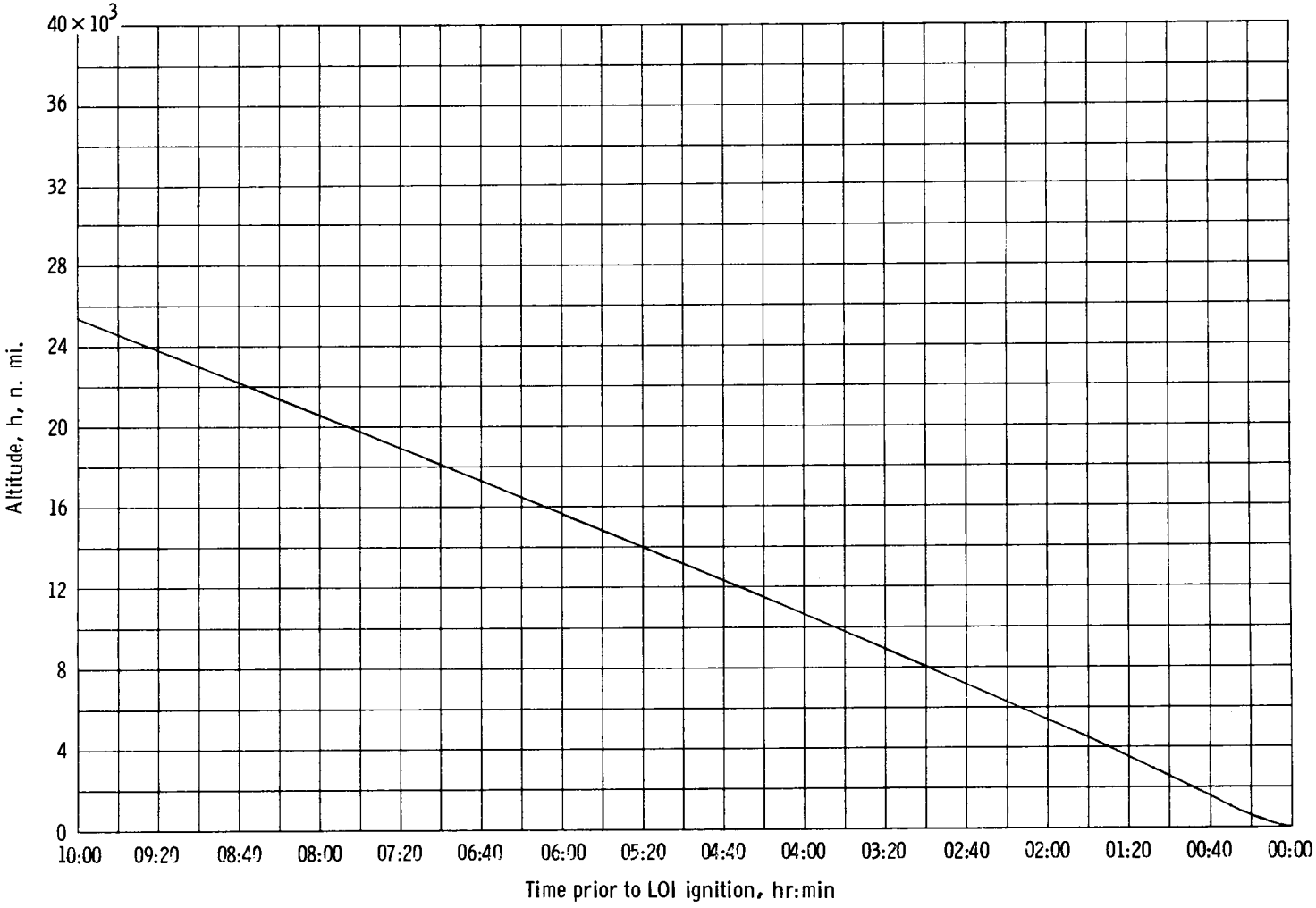
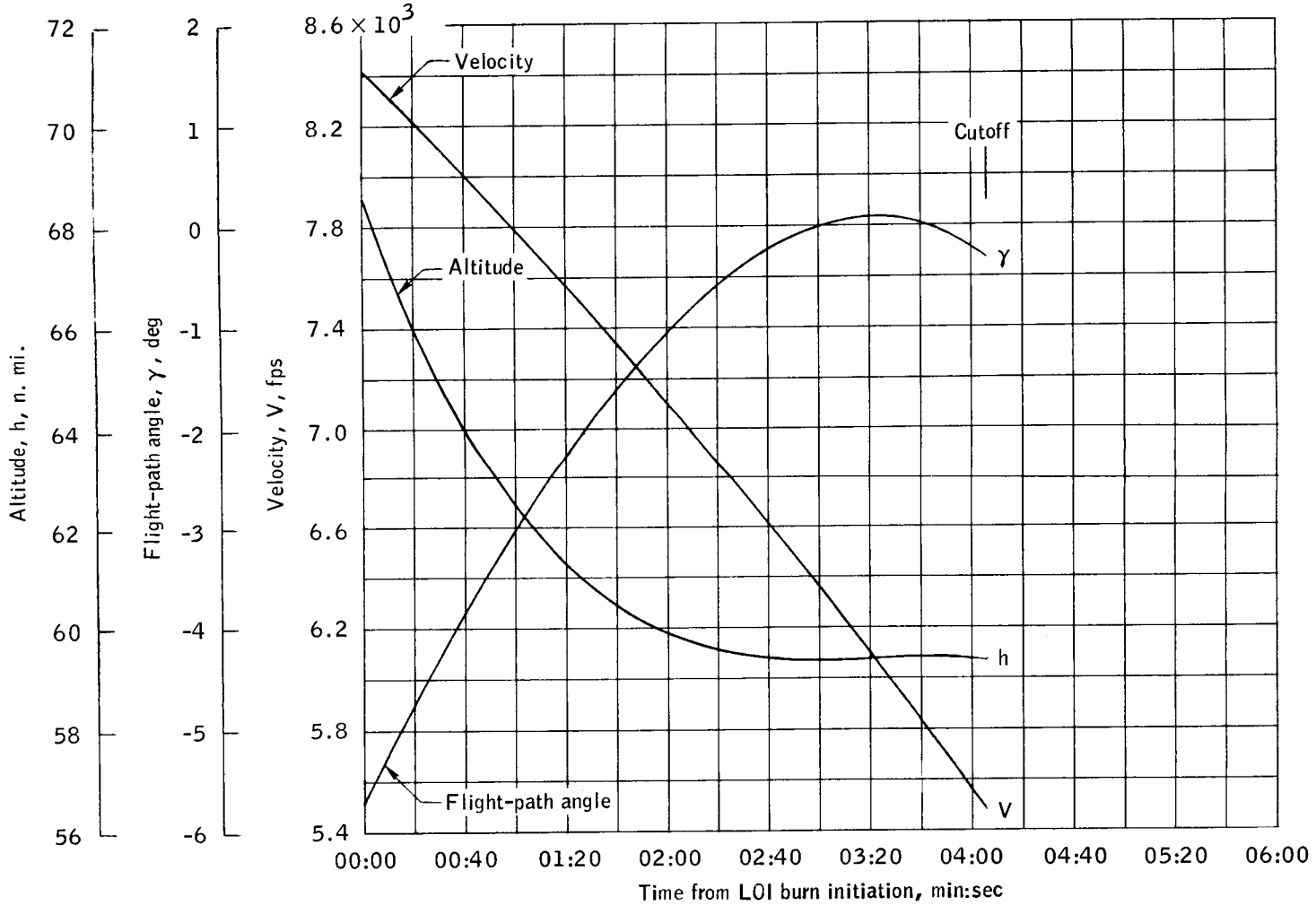
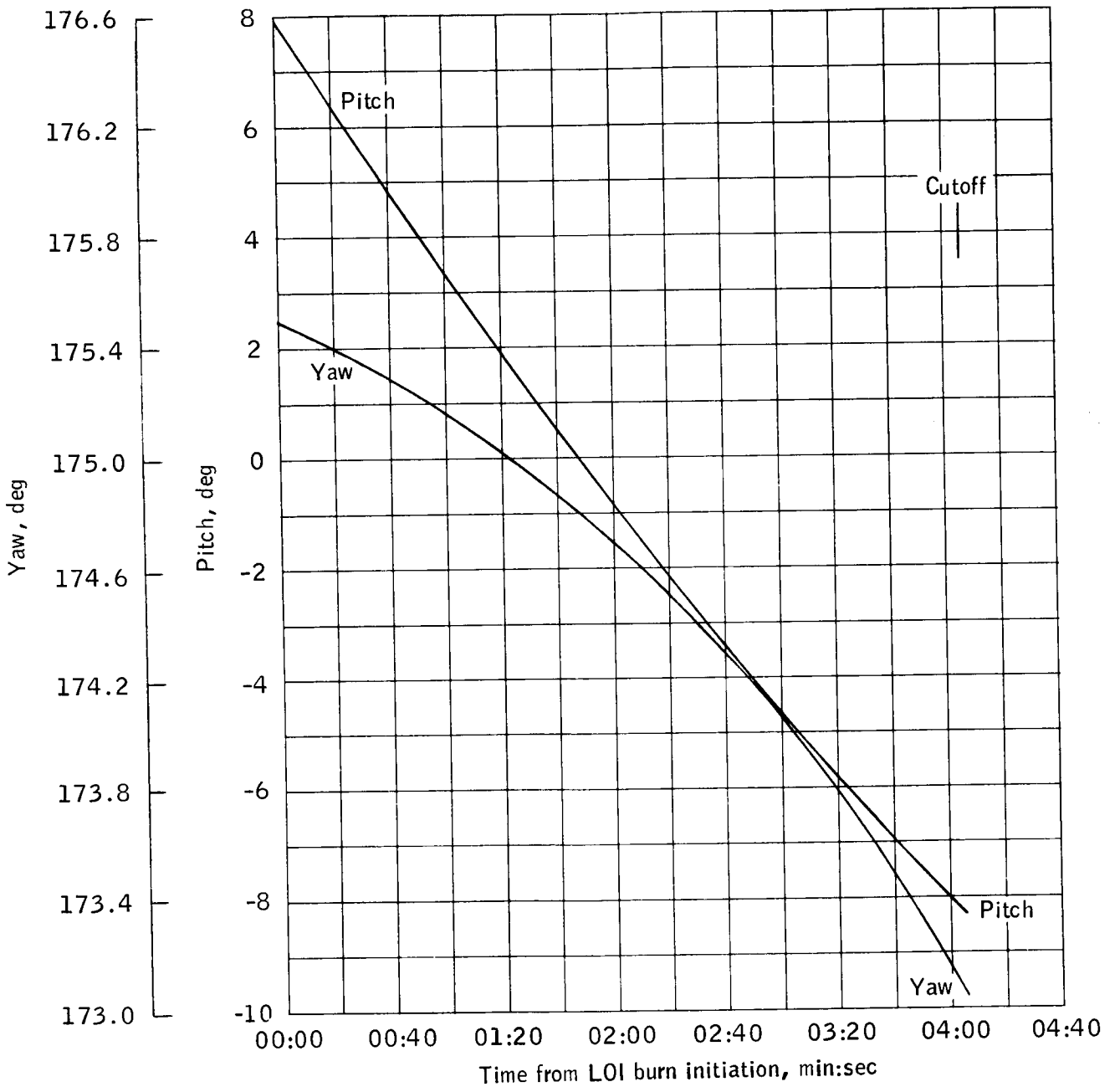


Figure 4.- Time history of altitude 10 hours prior to LOI ignition.



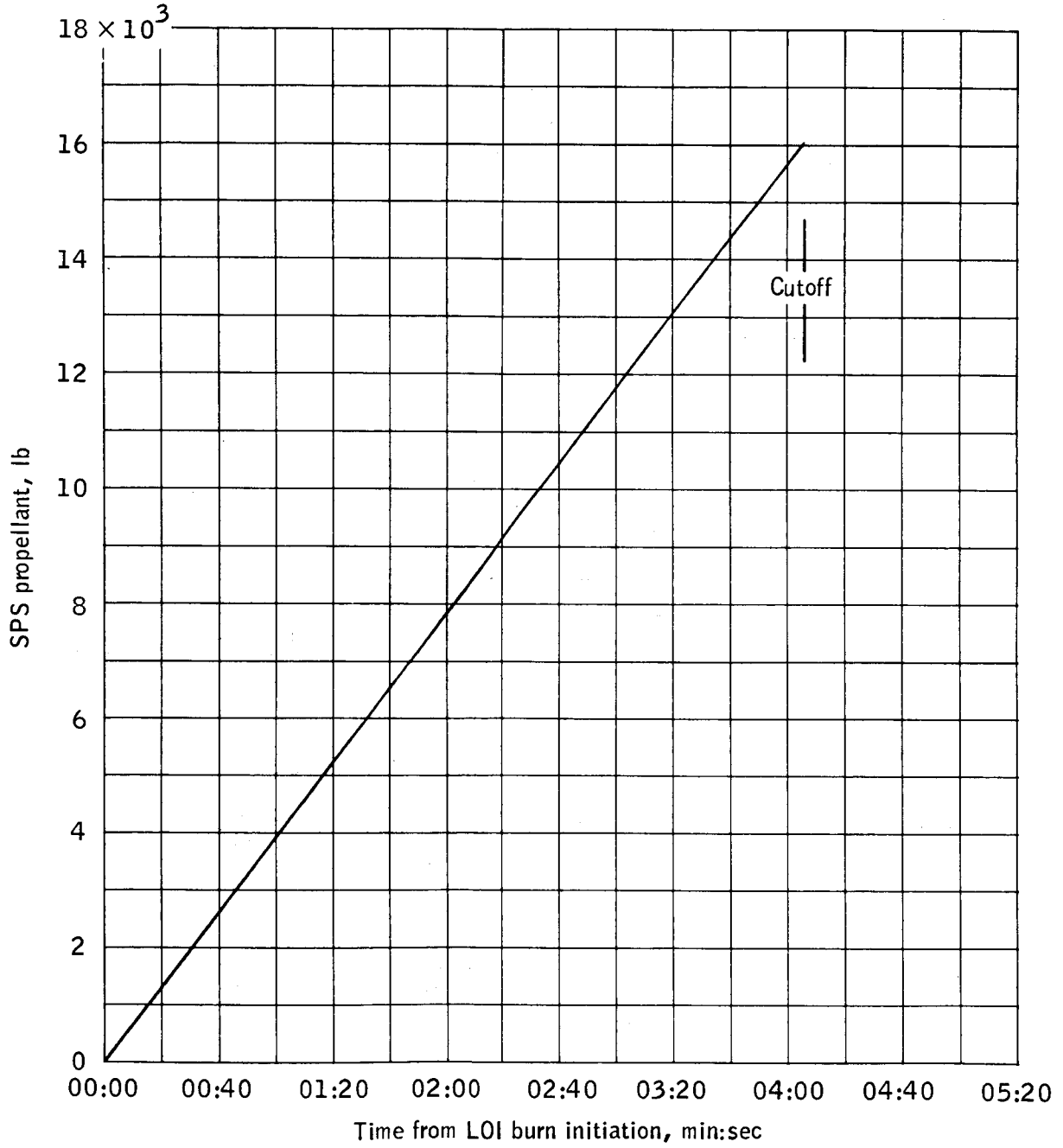
(a) Velocity, flight-path angle, and altitude versus time from LOI burn initiation.

Figure 5.- Time histories of trajectory parameters for the lunar orbit insertion phase.



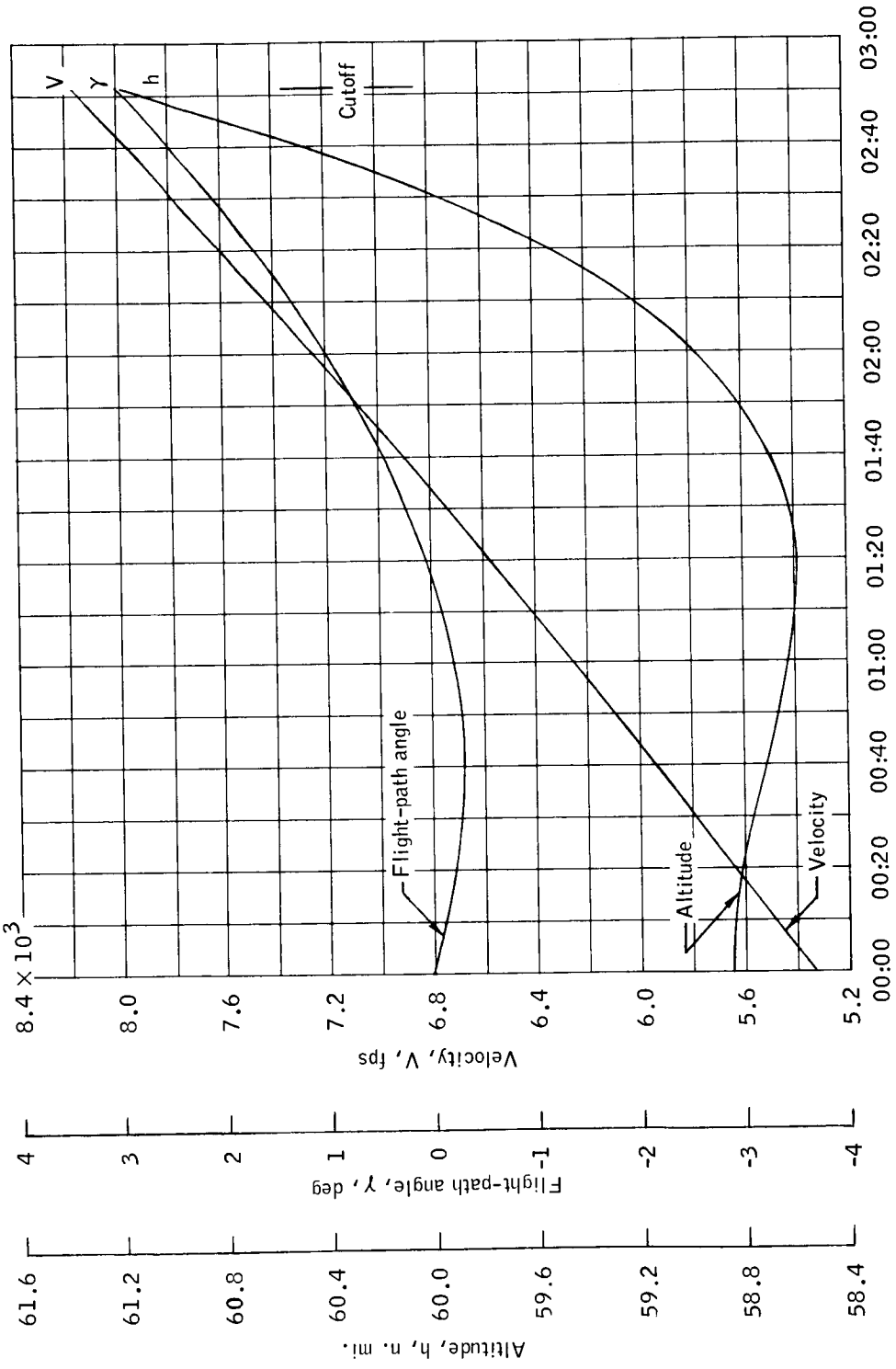
(b) Local horizontal pitch and yaw versus time from LOI burn initiation.

Figure 5.- Continued.



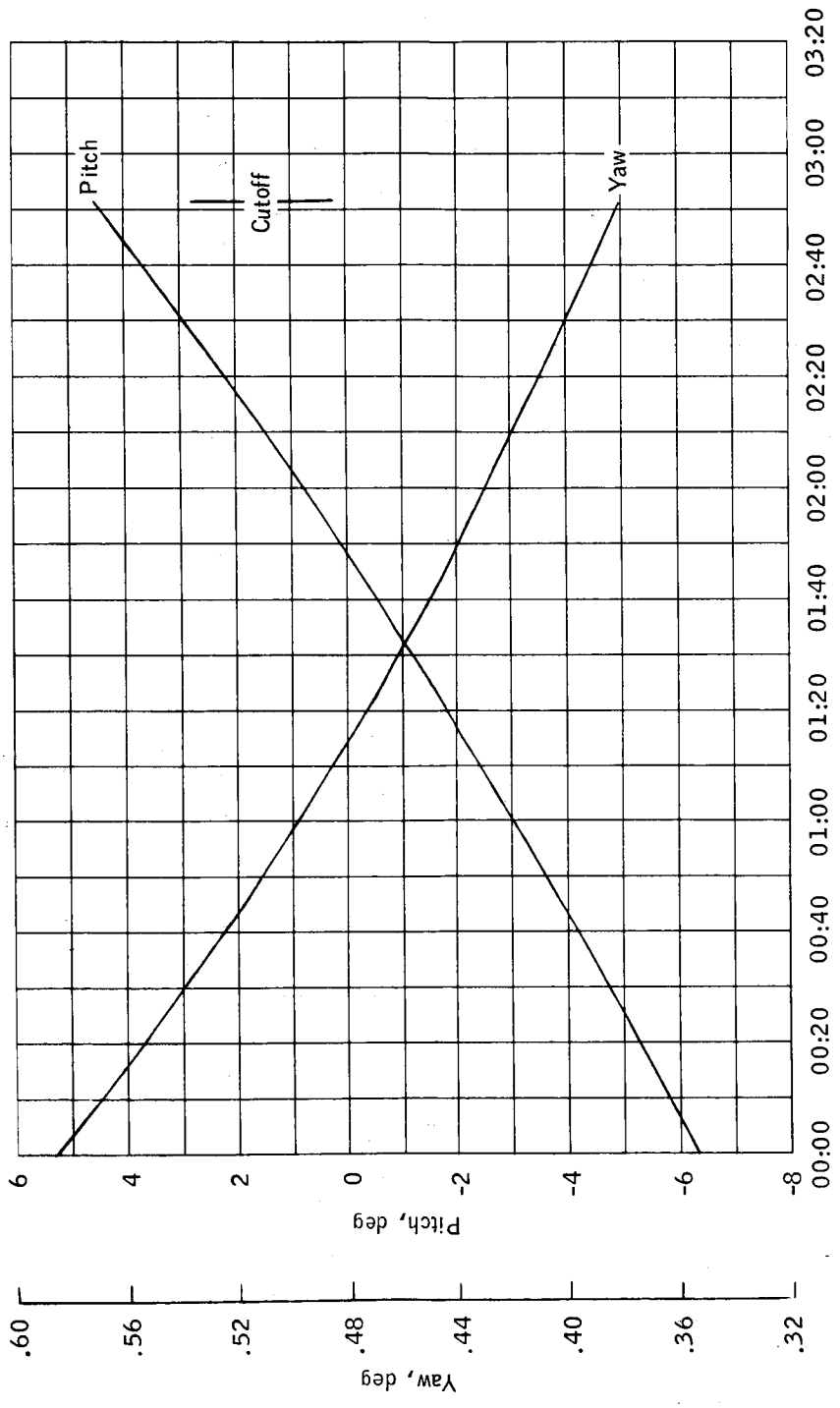
(c) SPS propellant versus time from LOI burn initiation.

Figure 5.- Concluded.



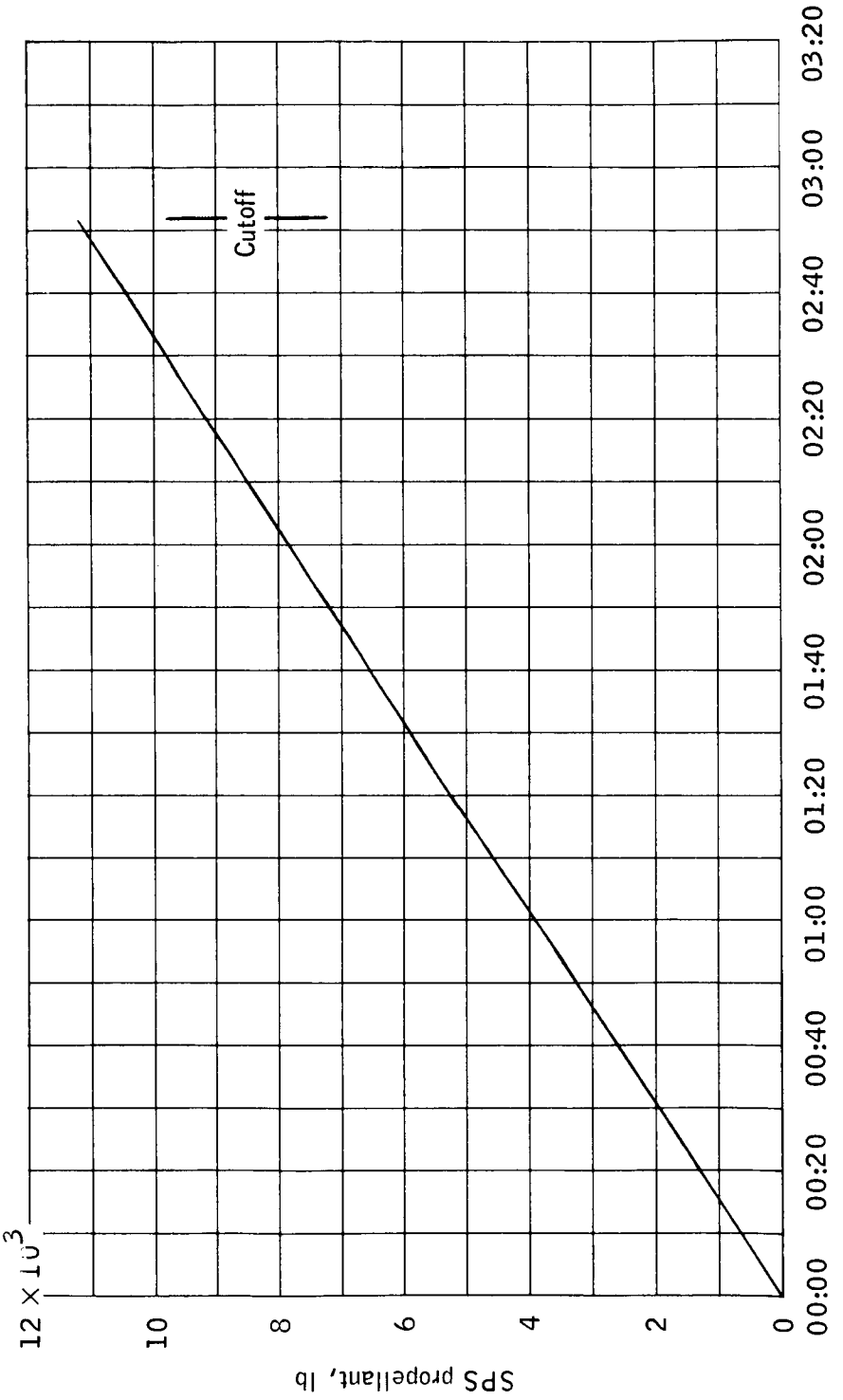
(a) Velocity, flight-path angle, and altitude versus time from TEI burn initiation.

Figure 6.- Time histories of trajectory parameters for the transearth injection phase.



(b) Local horizontal pitch and yaw versus time from TEI burn initiation.

Figure 6.- Continued.



(c) SPS propellant versus time from TEI burn initiation.

Figure 6.- Concluded.

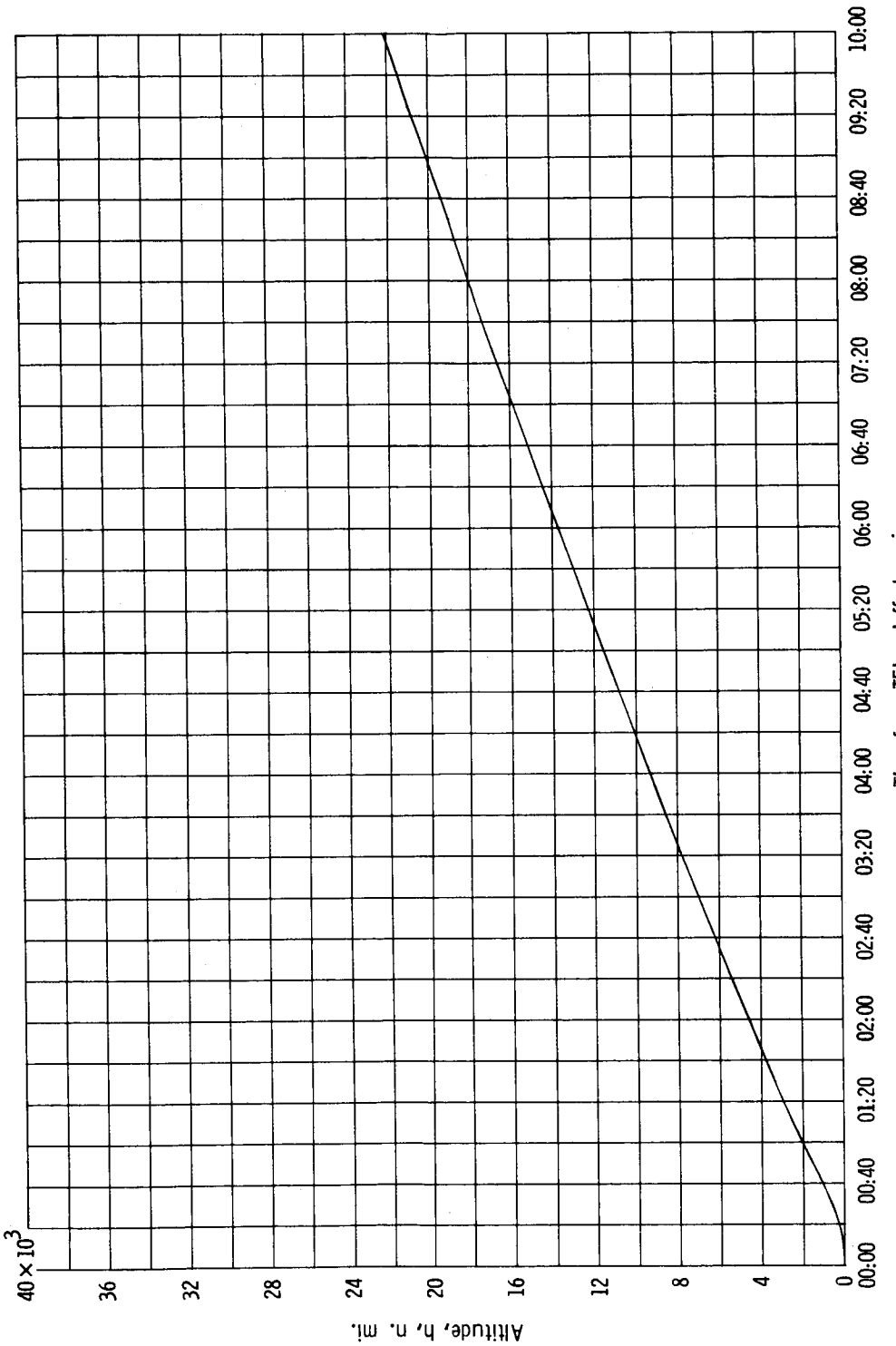


Figure 7.- Time history of altitude for first 10 hours of transearth coast phase.

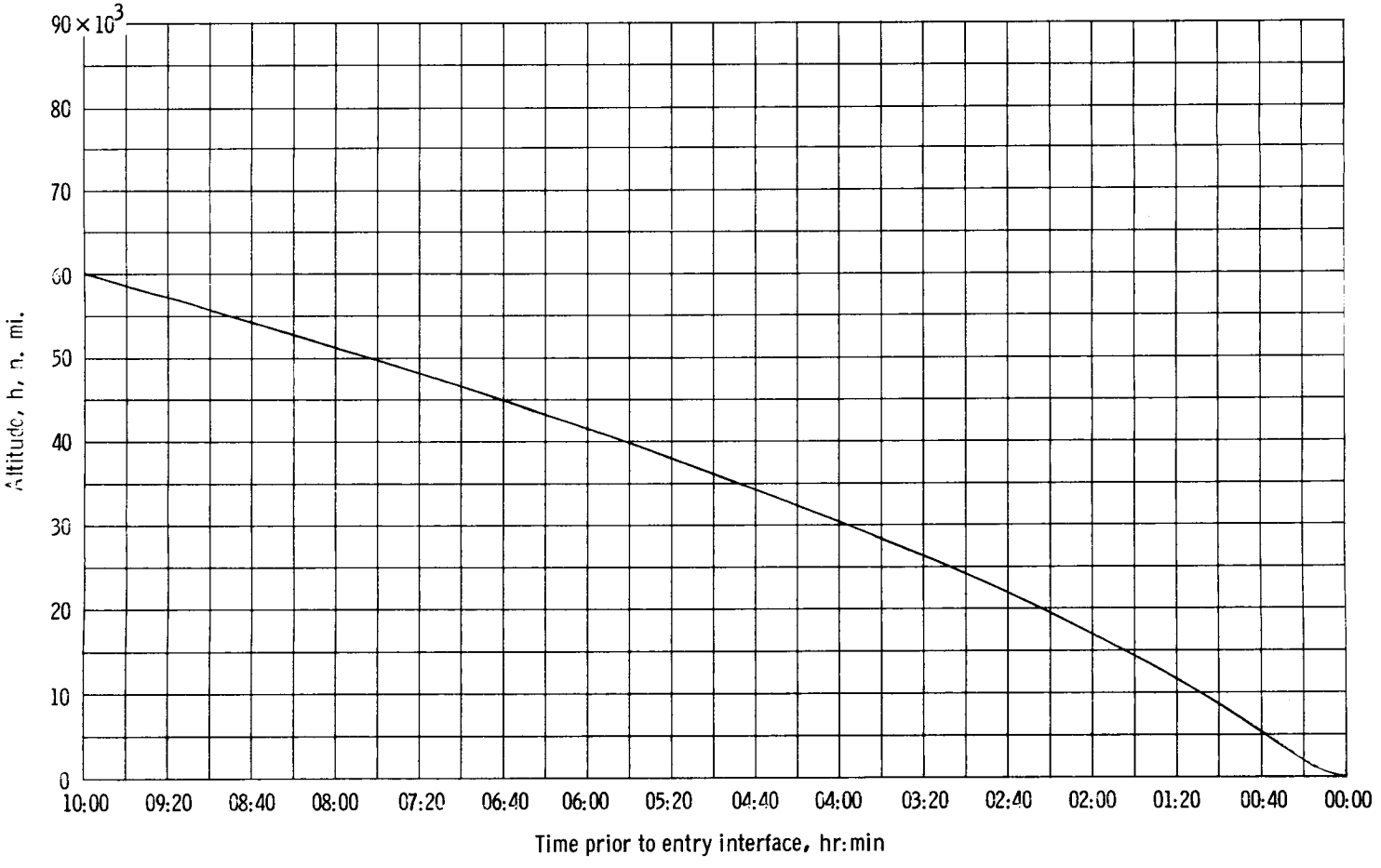


Figure 8. - Time history of altitude 10 hours prior to entry interface.

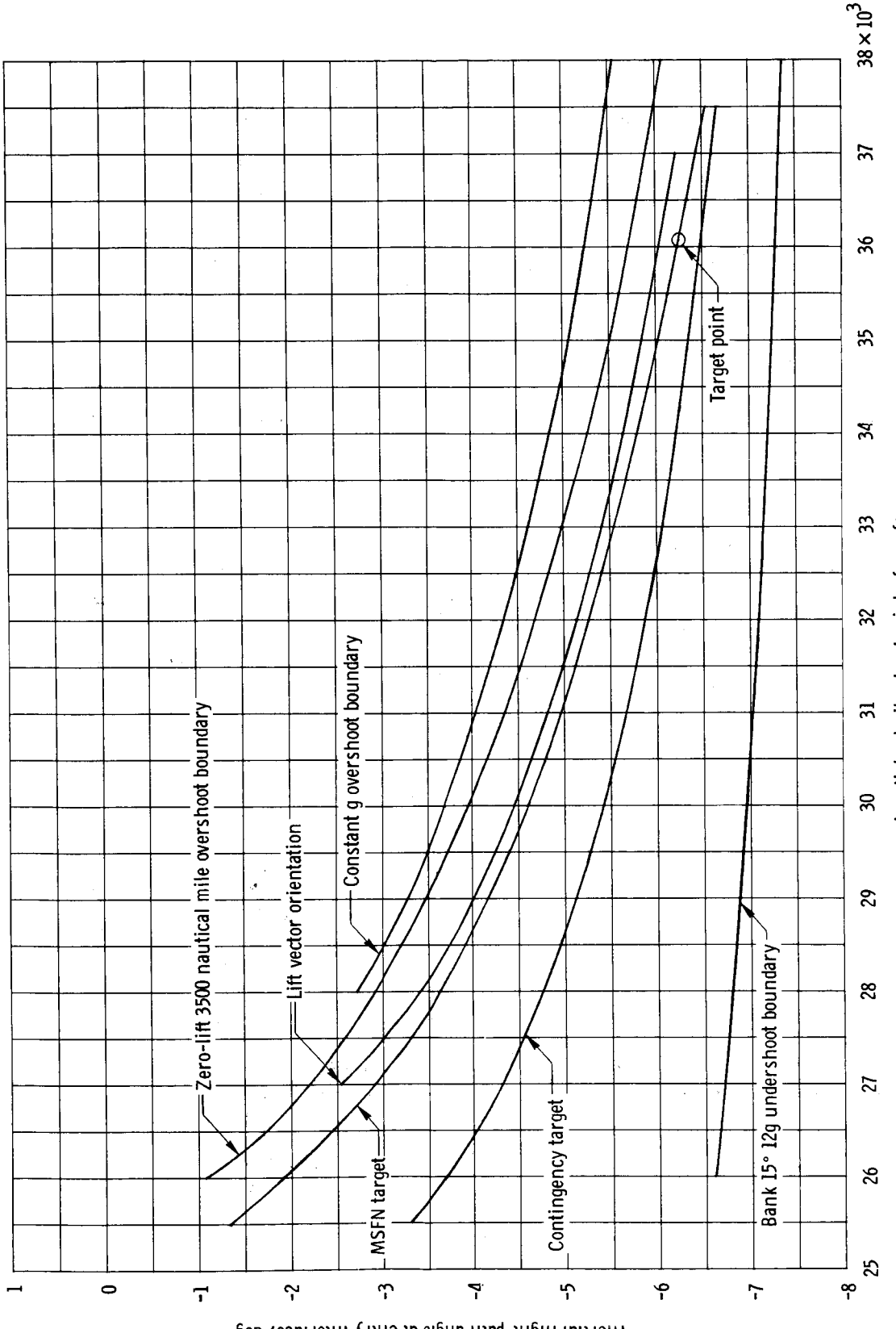


Figure 9.- Reentry corridor.

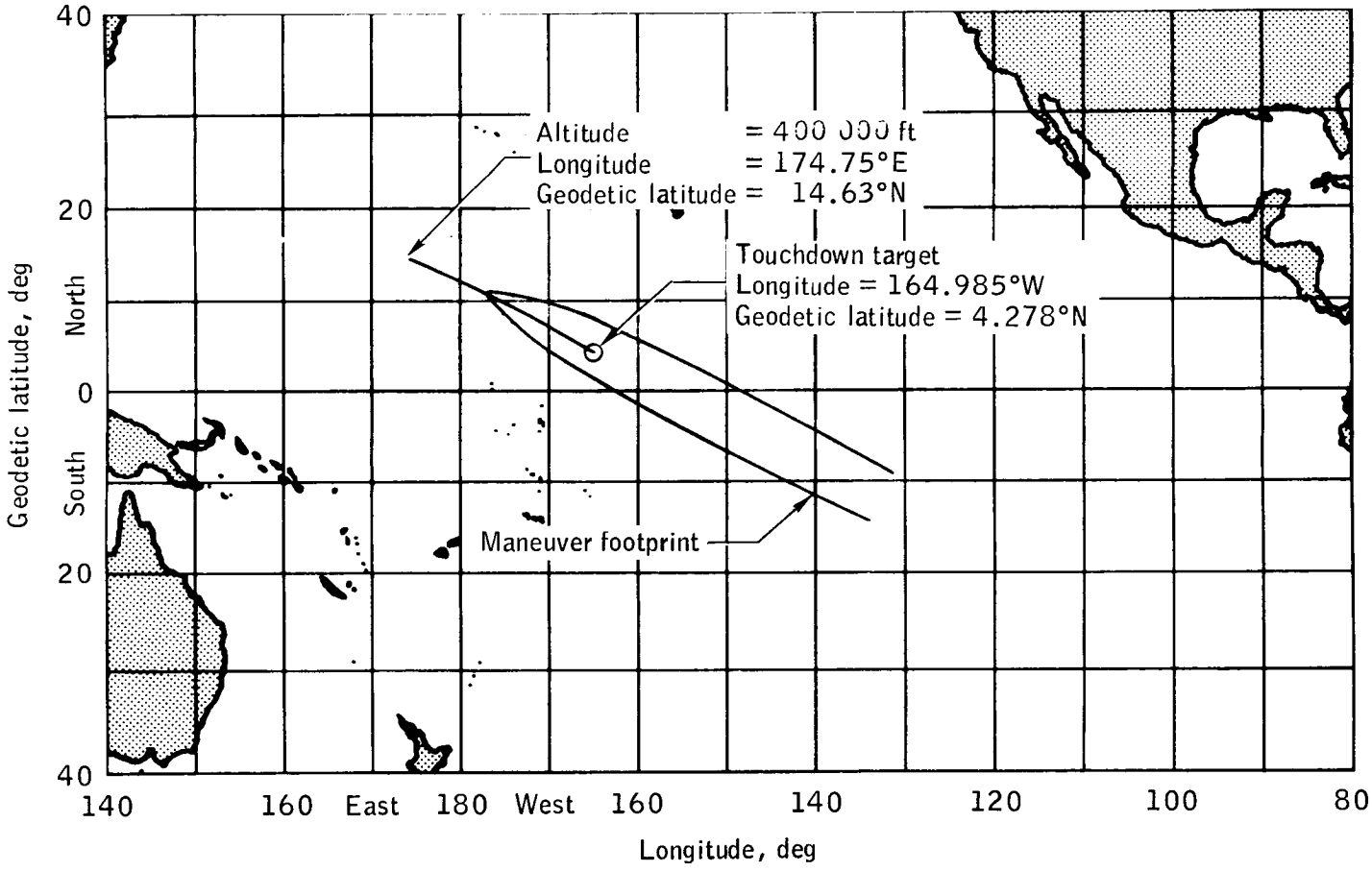


Figure 10.- Maneuver footprint and nominal ground track.

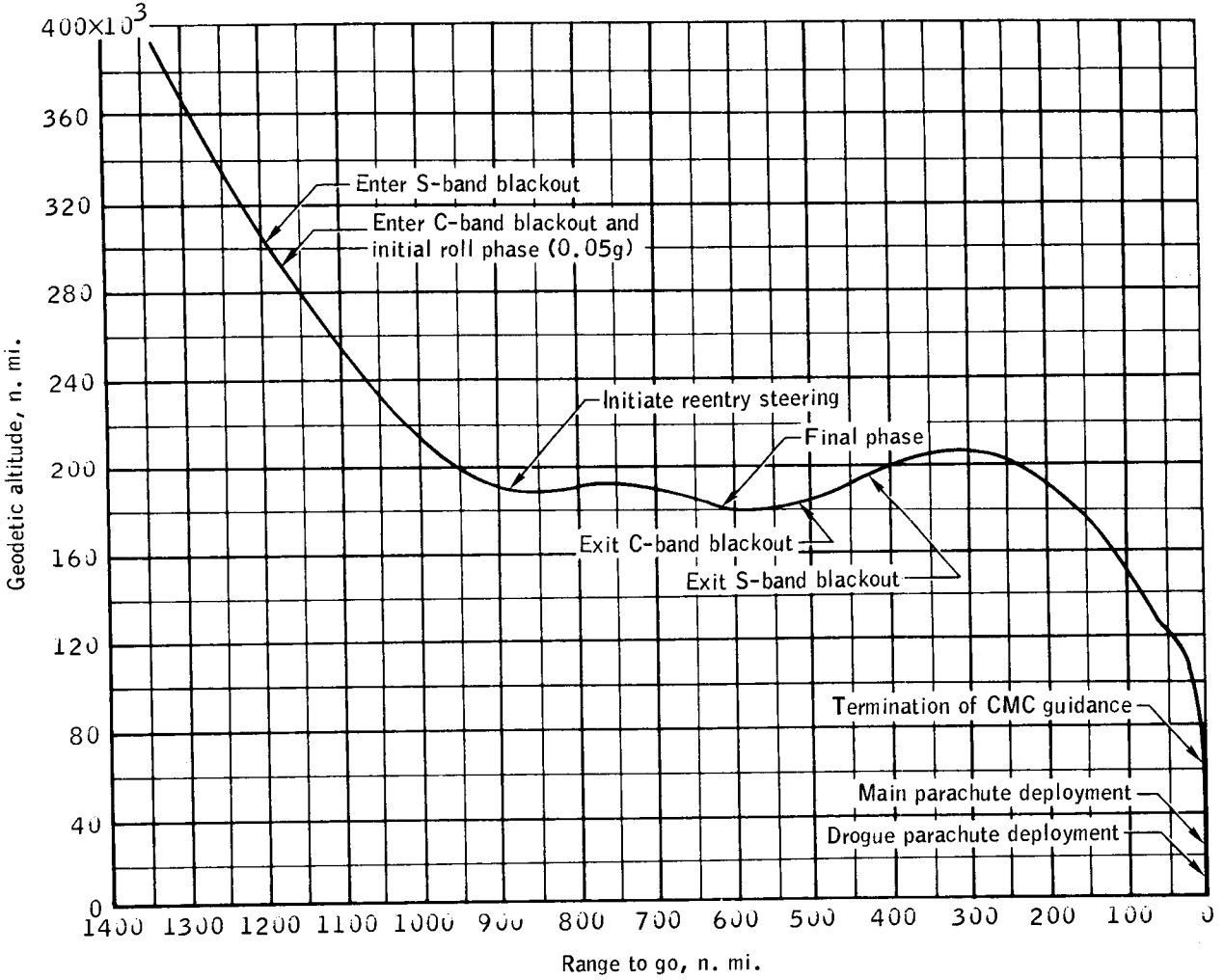


Figure 11.- Geodetic altitude versus range to go.

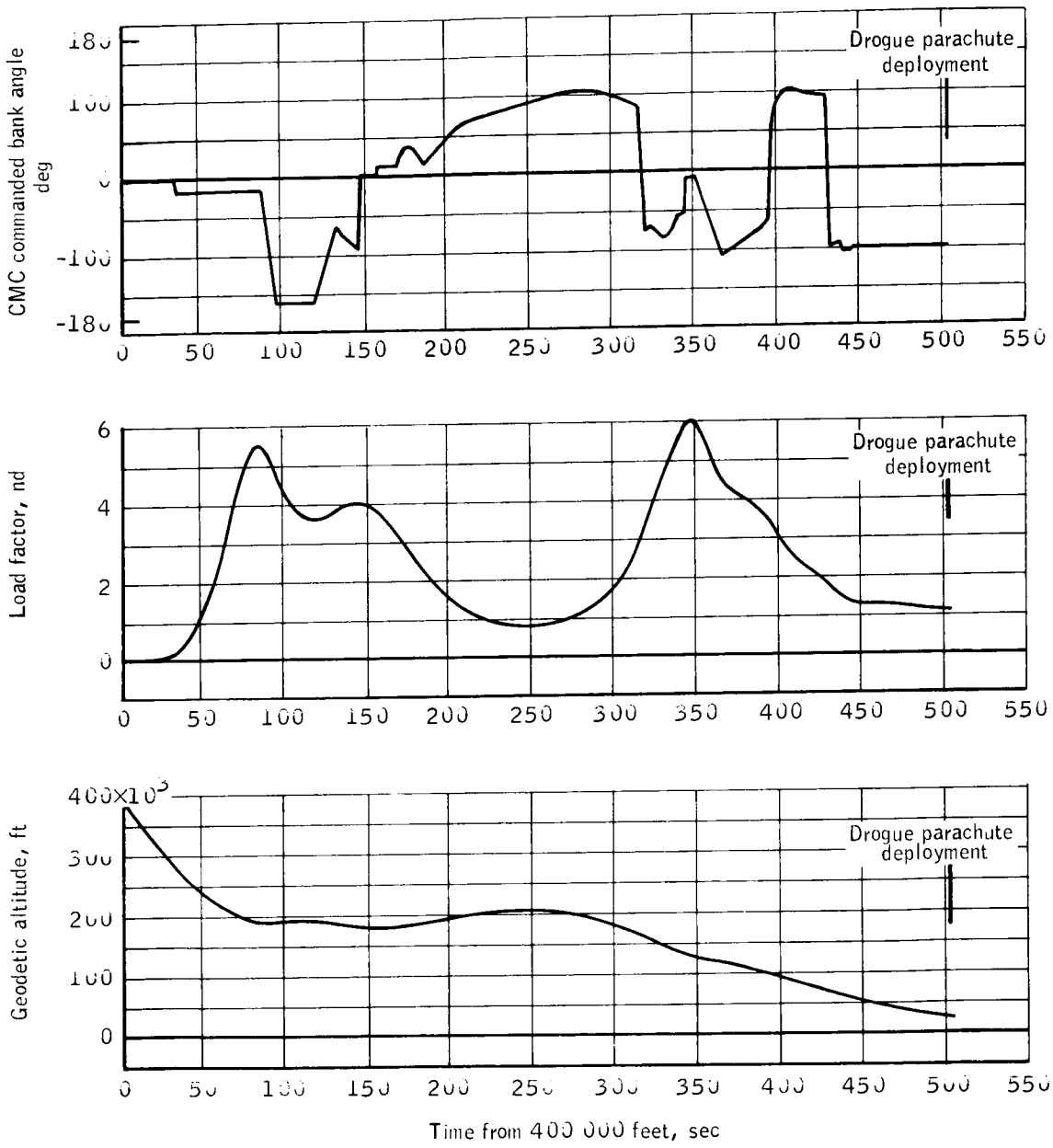


Figure 12.- CMC commanded bank angle, load factor, and altitude time histories.

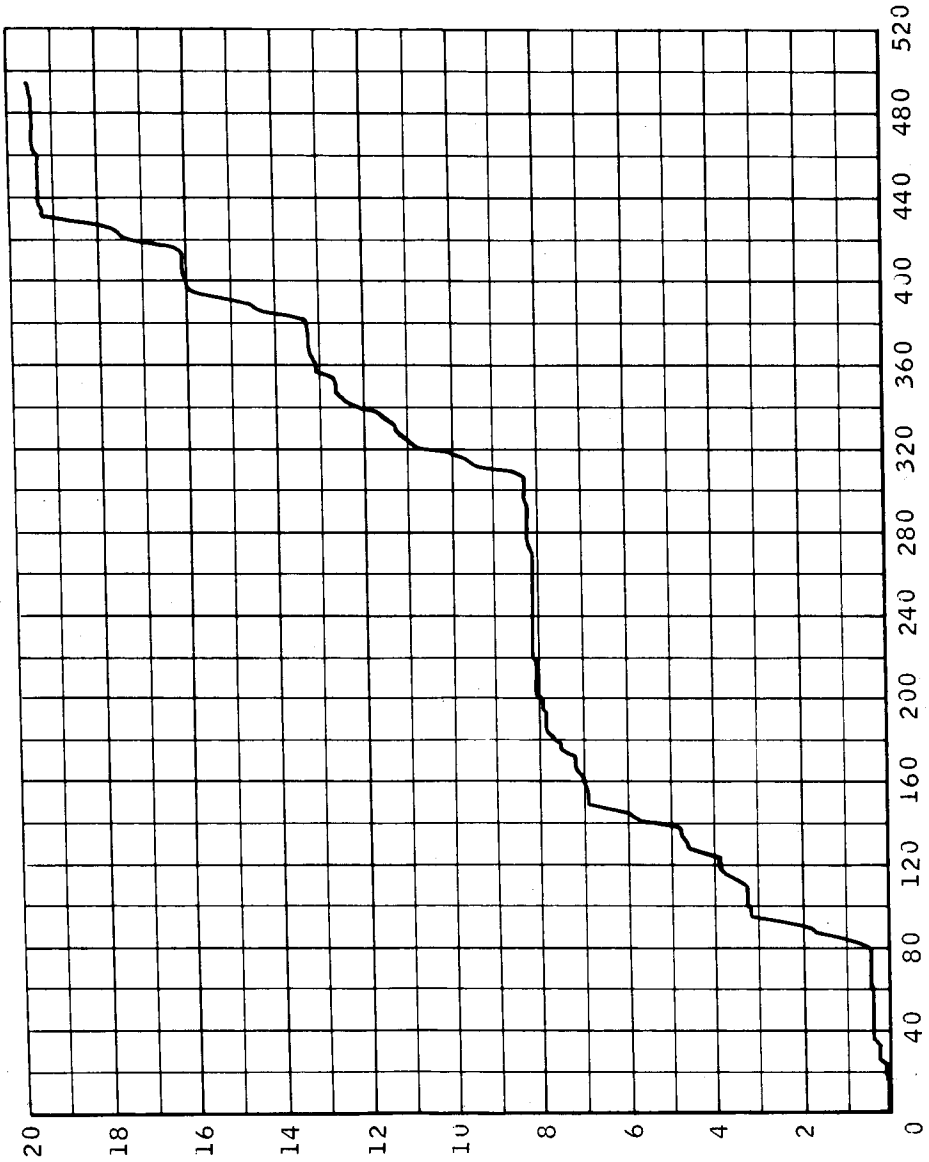


Figure 13.- RCS propellant consumption from 0.05g.

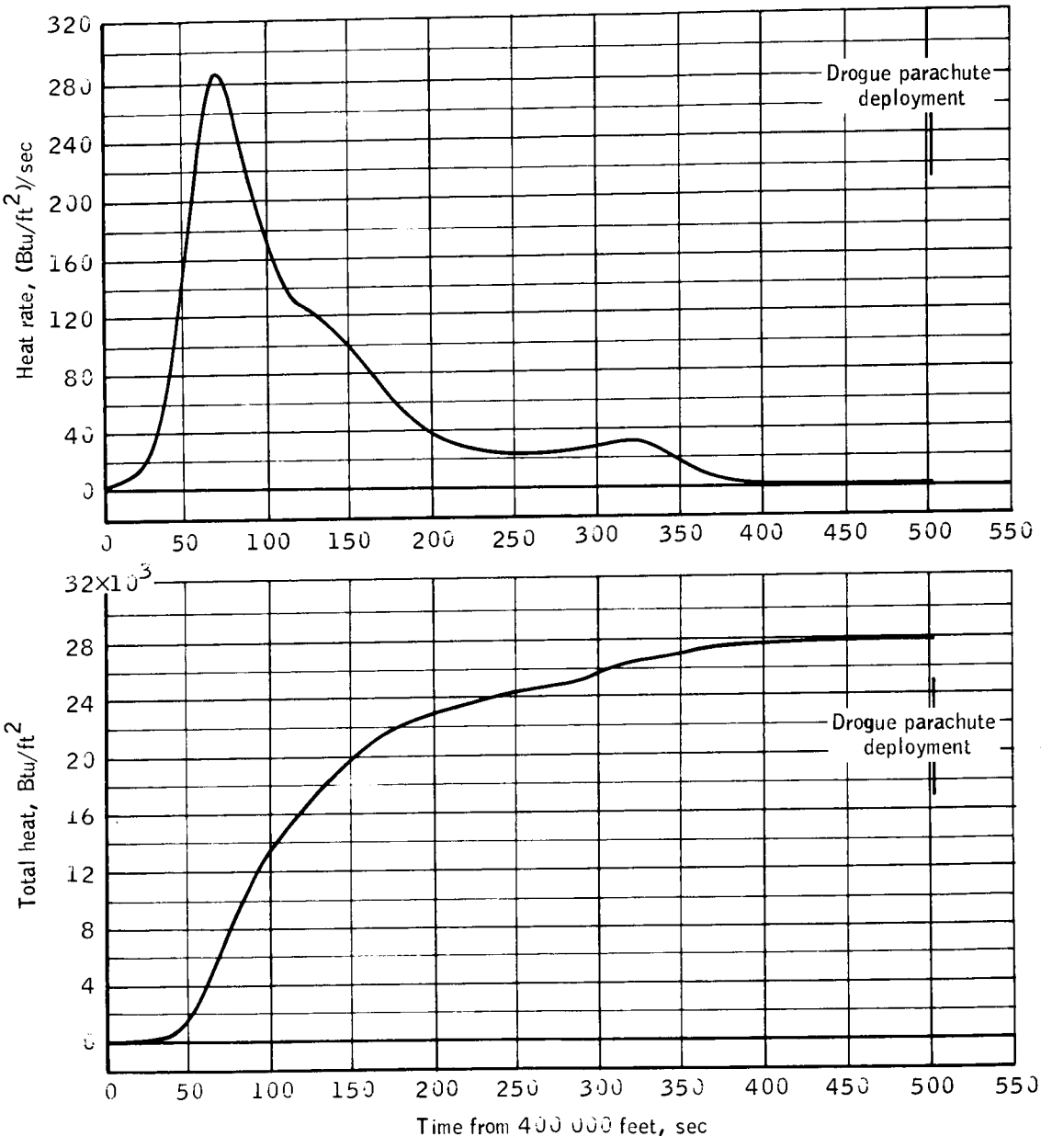


Figure 14.- Aerodynamic heating rate and heat load time histories.

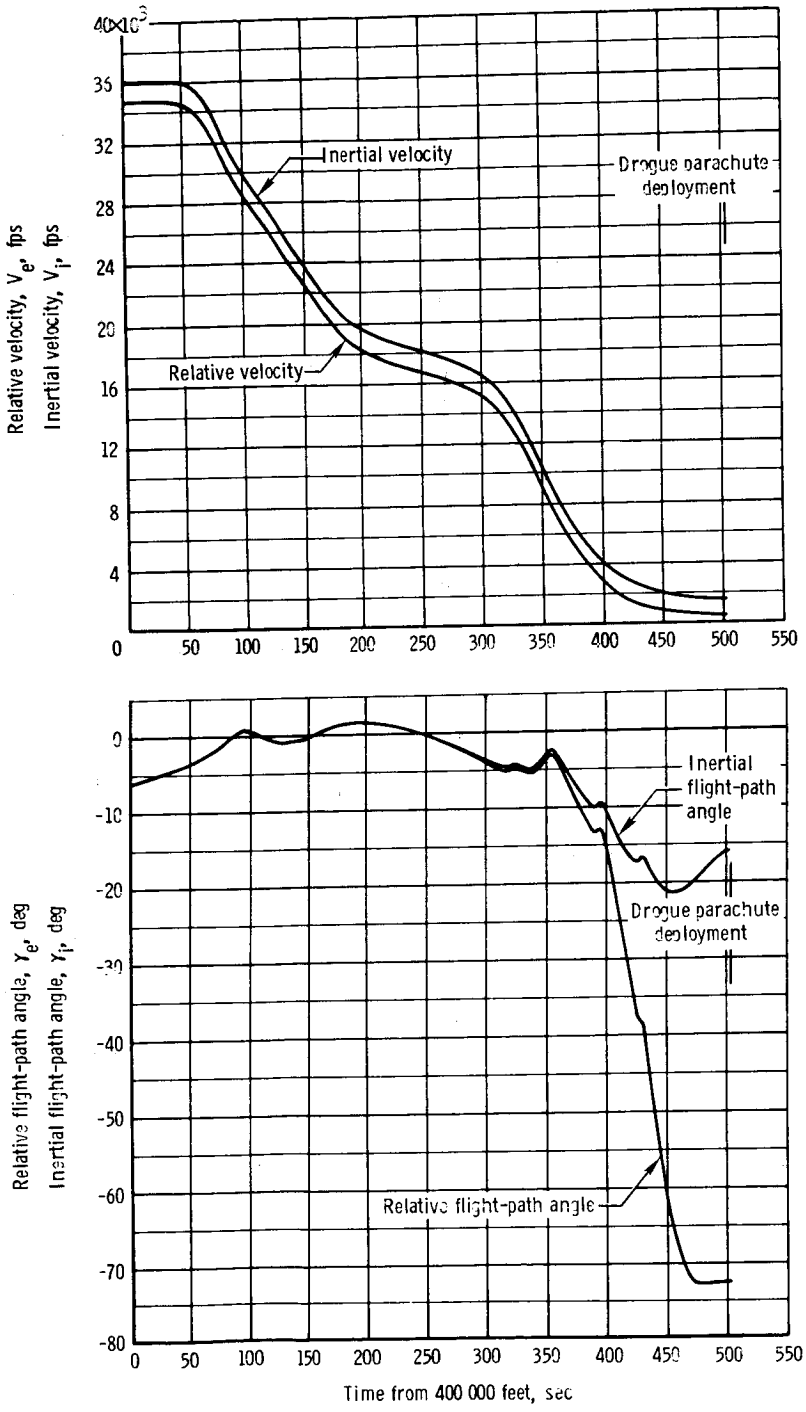


Figure 15.- Reentry velocity and flight-path angle time histories.

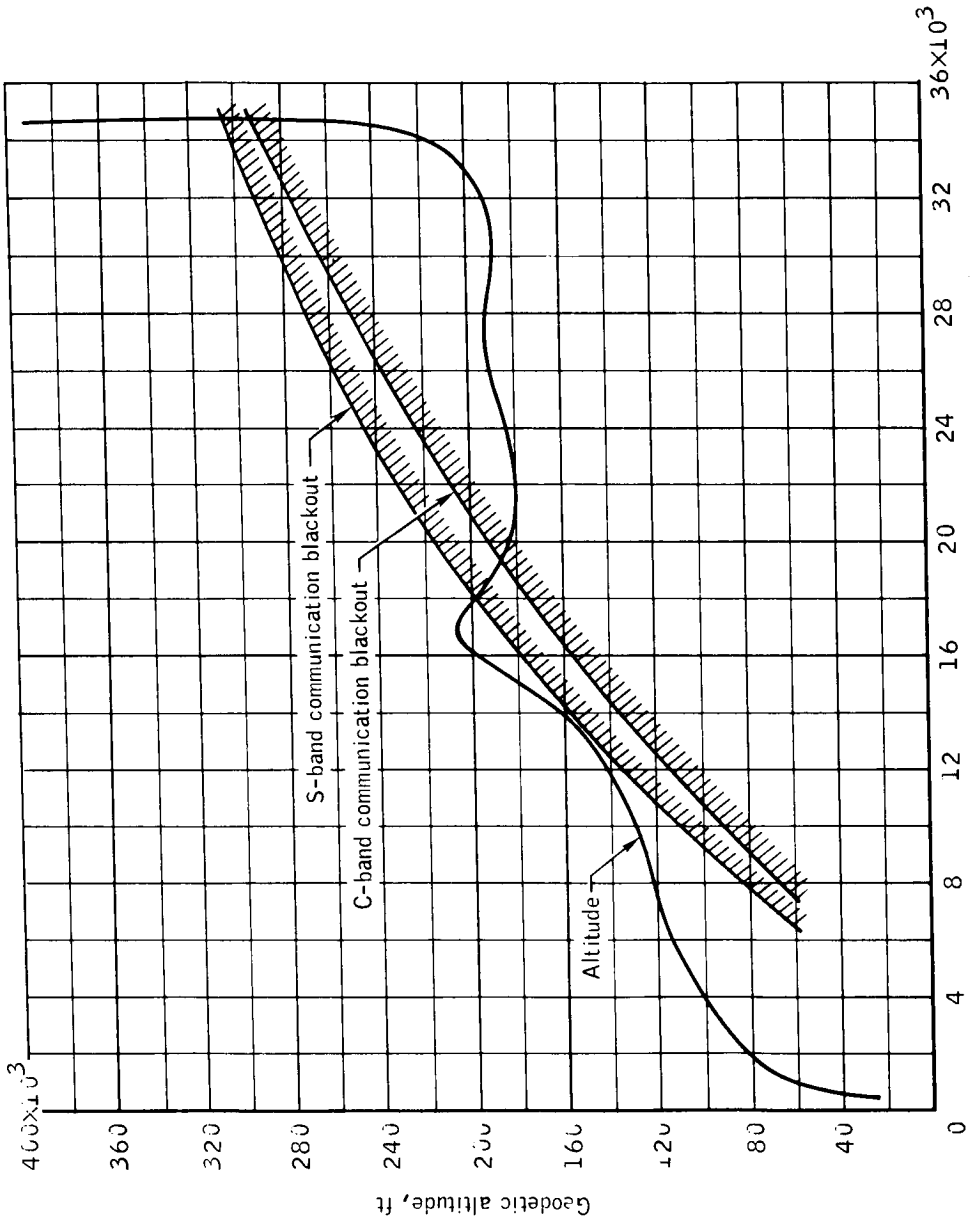


Figure 16.- Communications blackout.

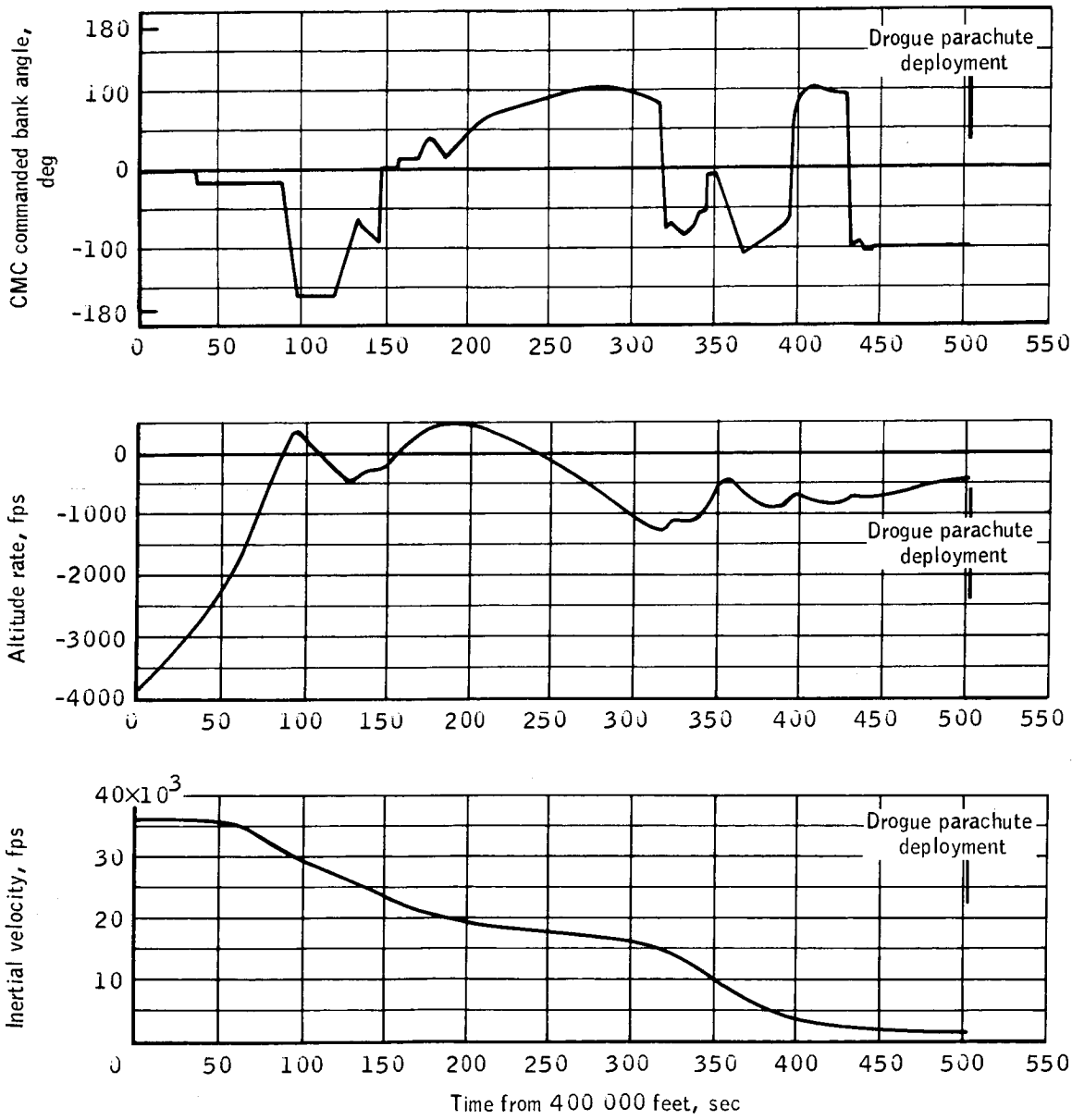


Figure 17.- CMC commanded bank angle, altitude rate and inertial velocity time histories.

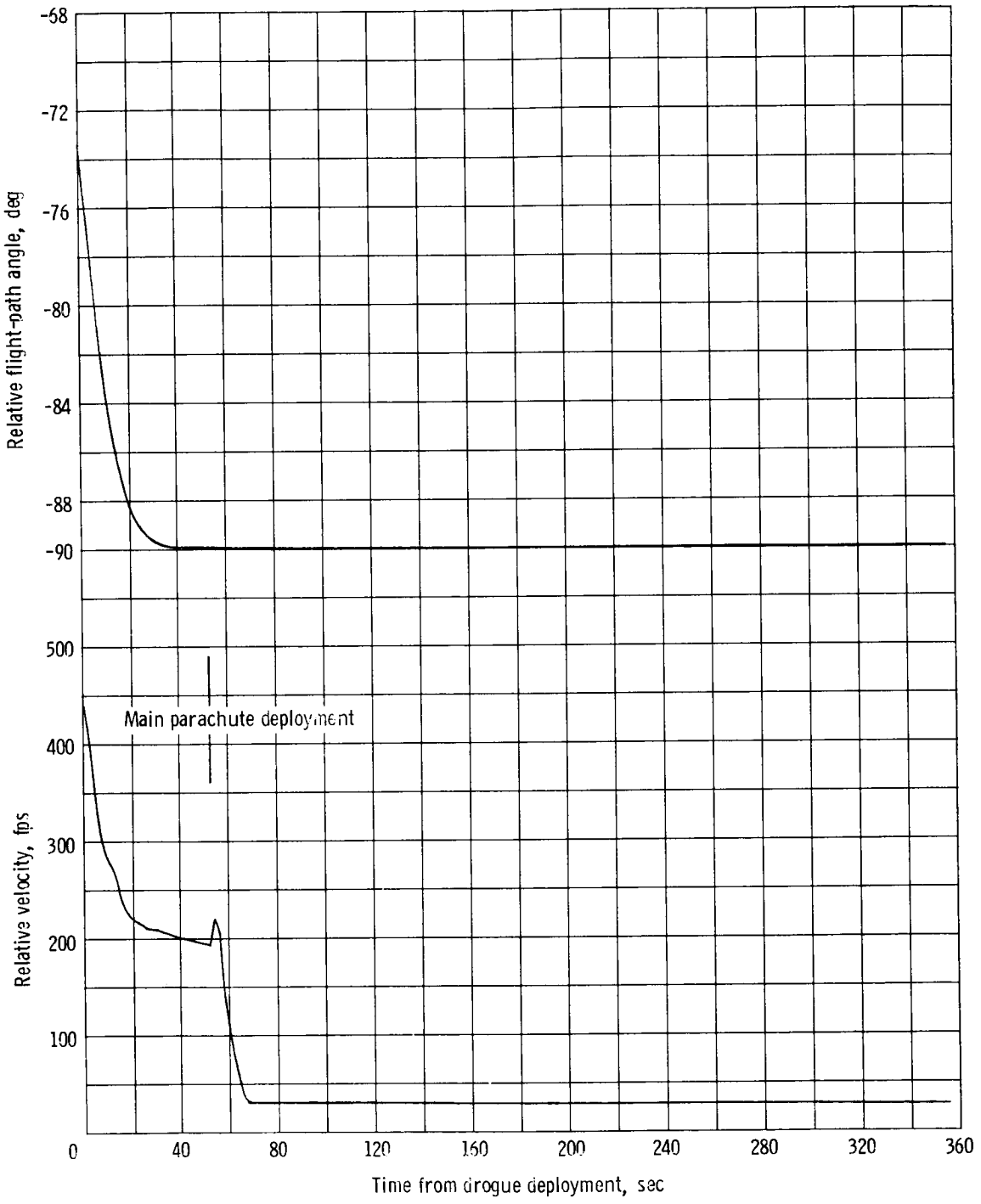


Figure 18.- Relative velocity and relative flight-path angle time histories from drogue parachute deployment.

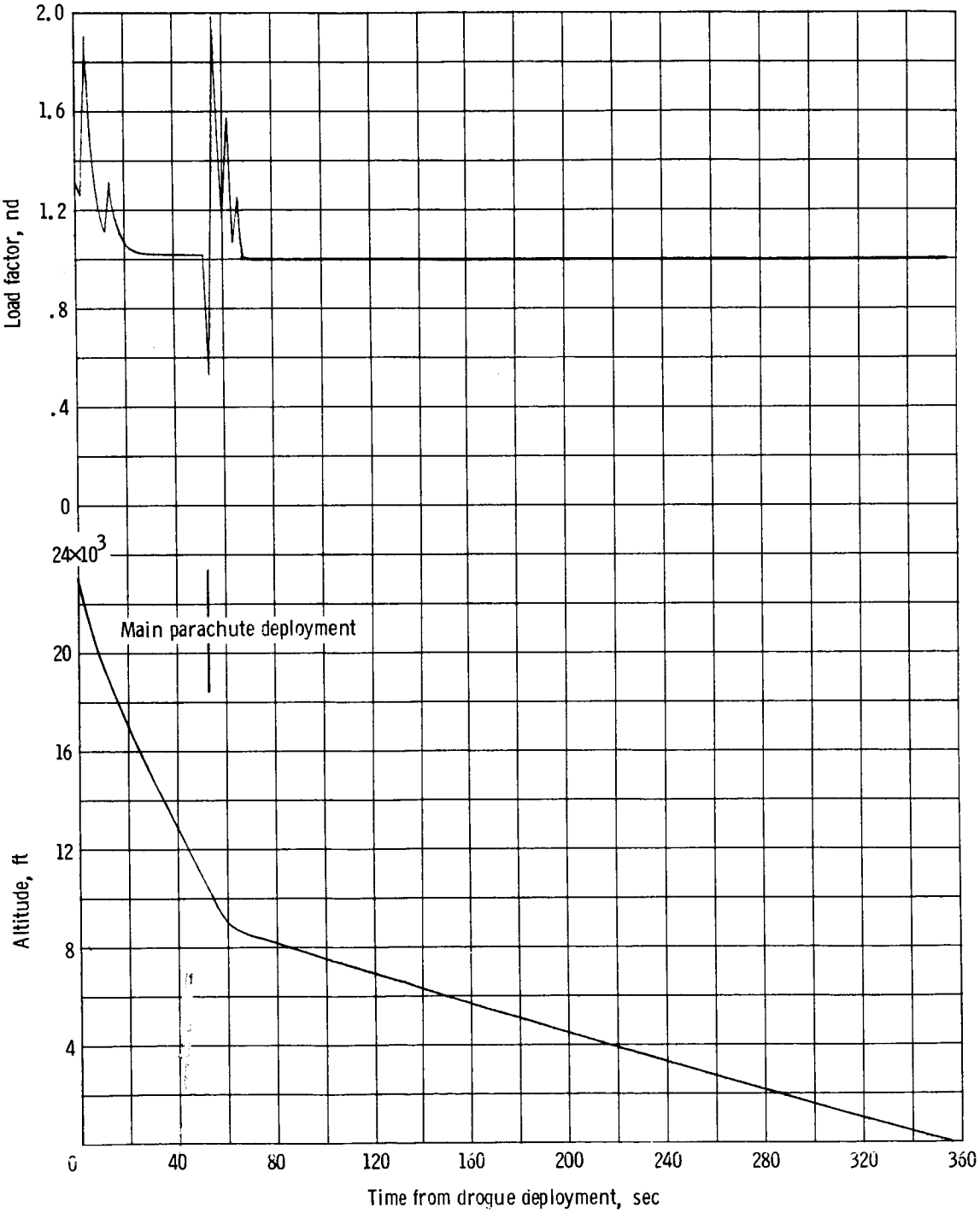
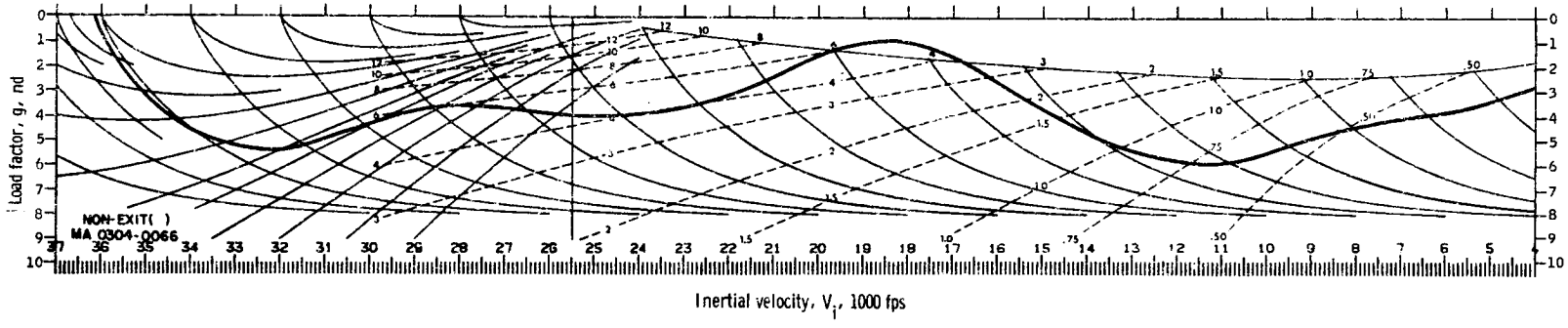
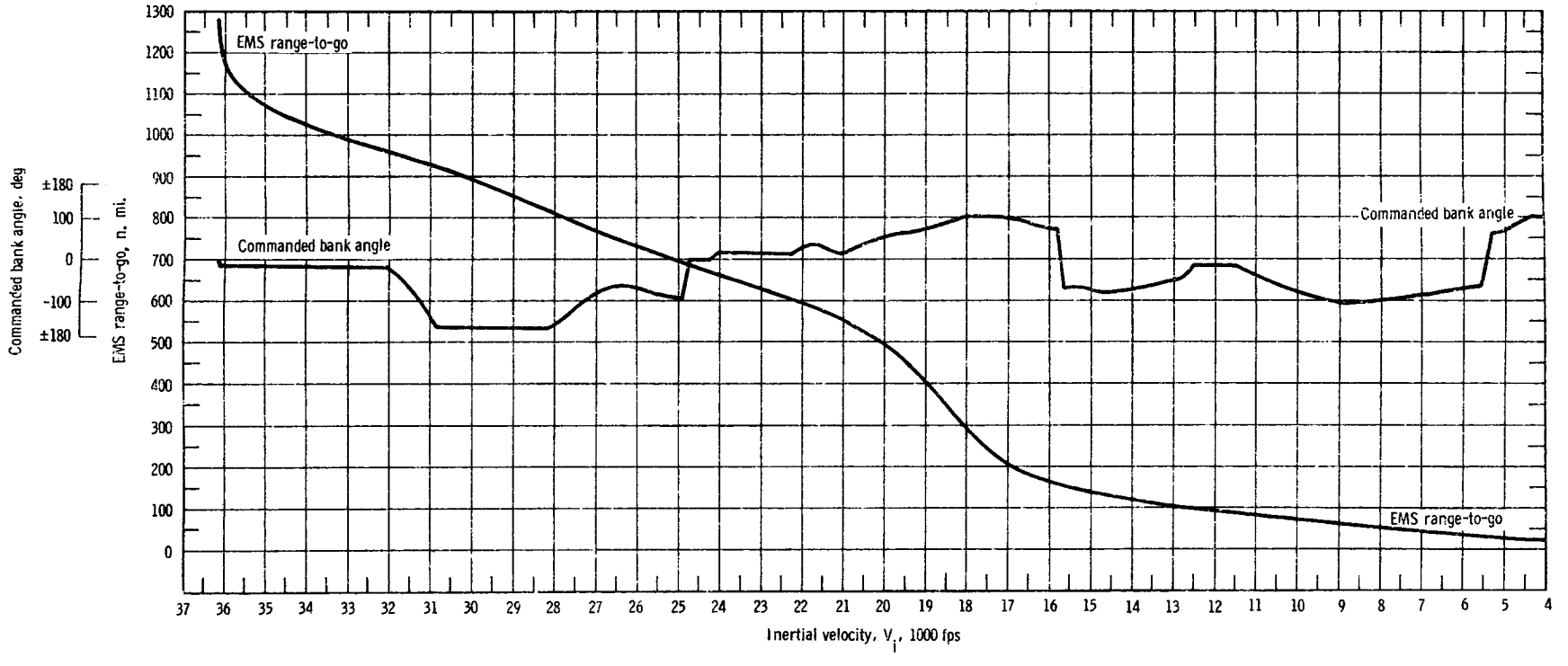


Figure 19.- Altitude and load factor time histories from drogue parachute deployment.

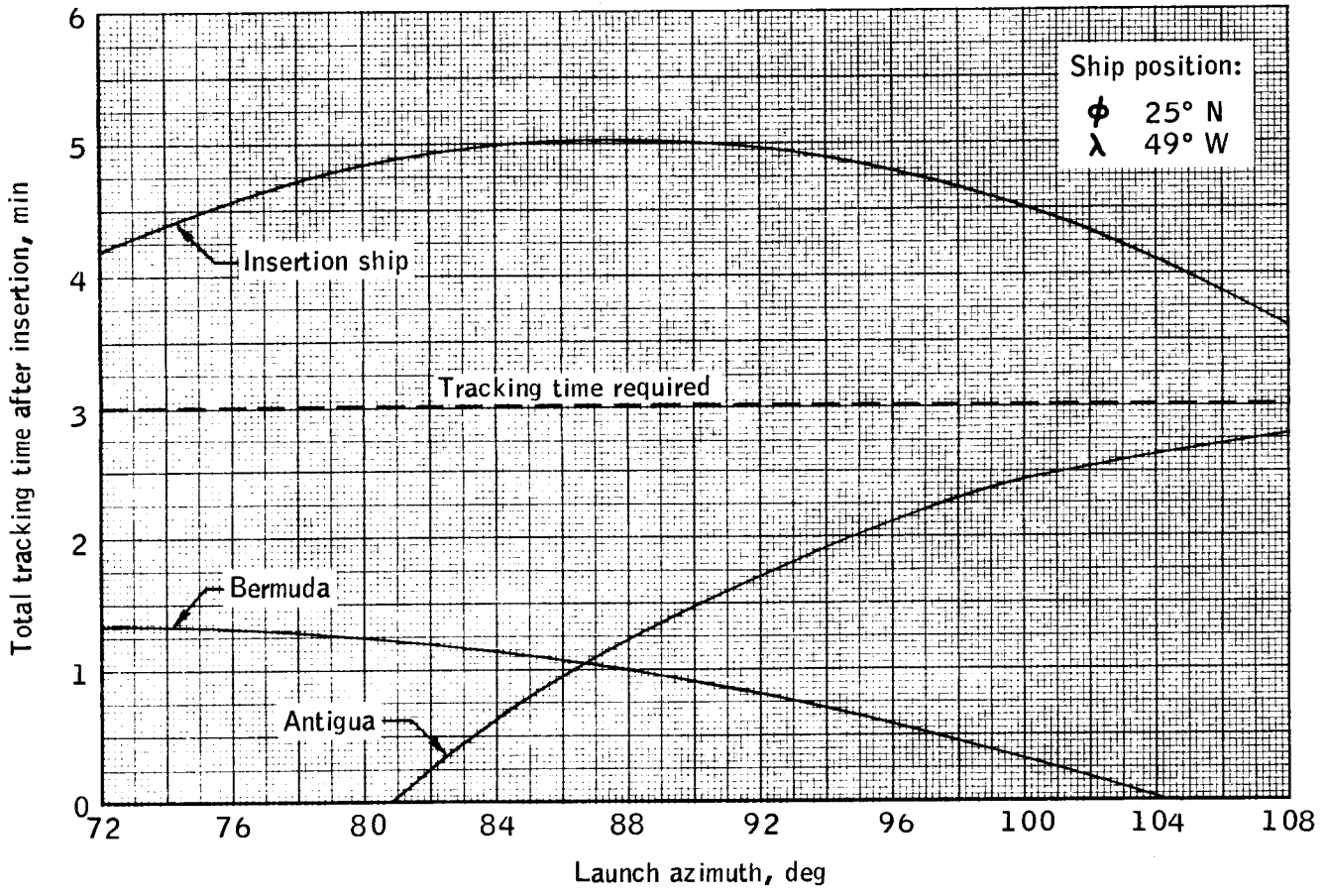


(a) Load factor versus inertial velocity.



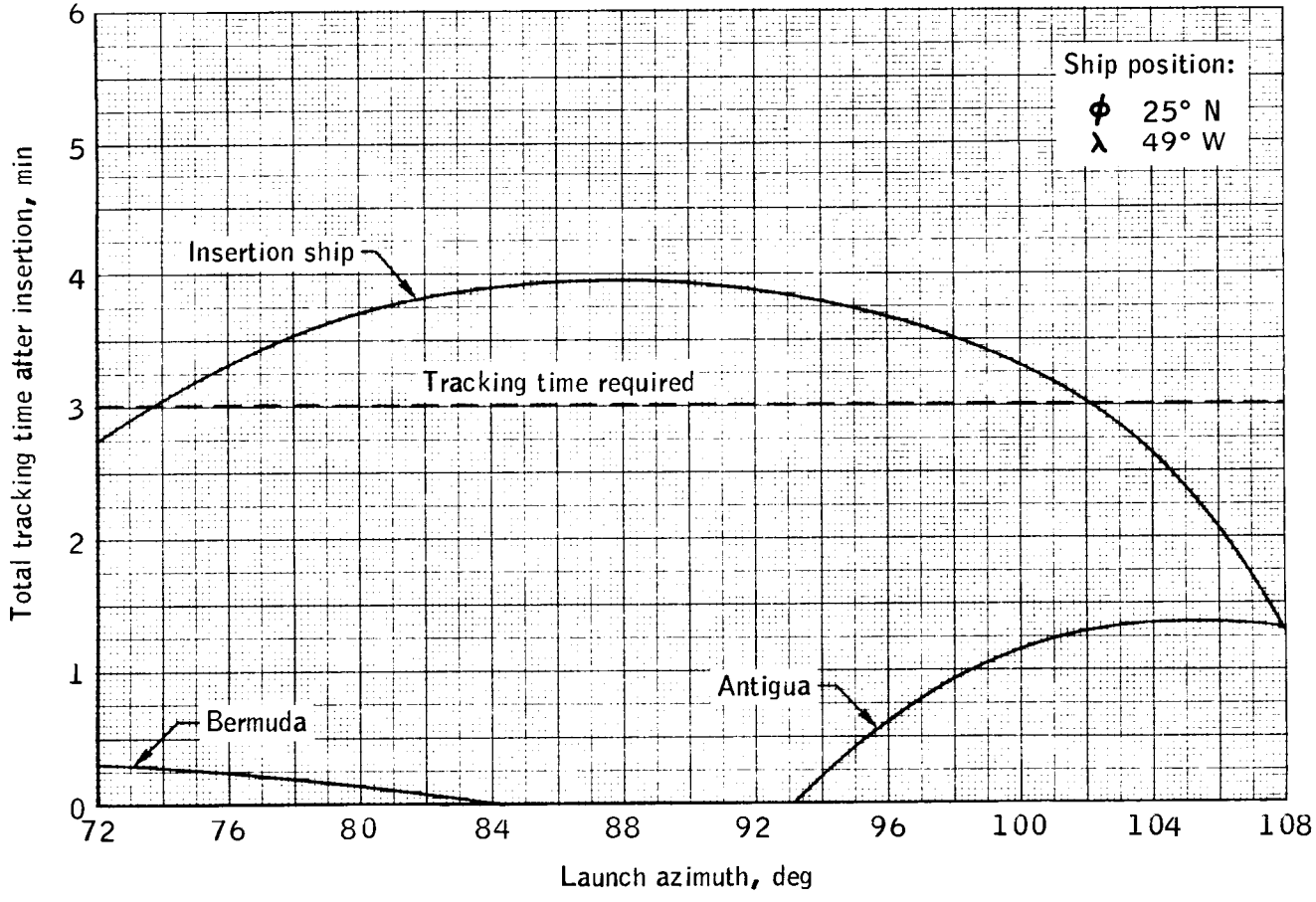
(b) CMC commanded bank angle and EMS range-to-go versus inertial velocity.

Figure 20. - EMS parameters.



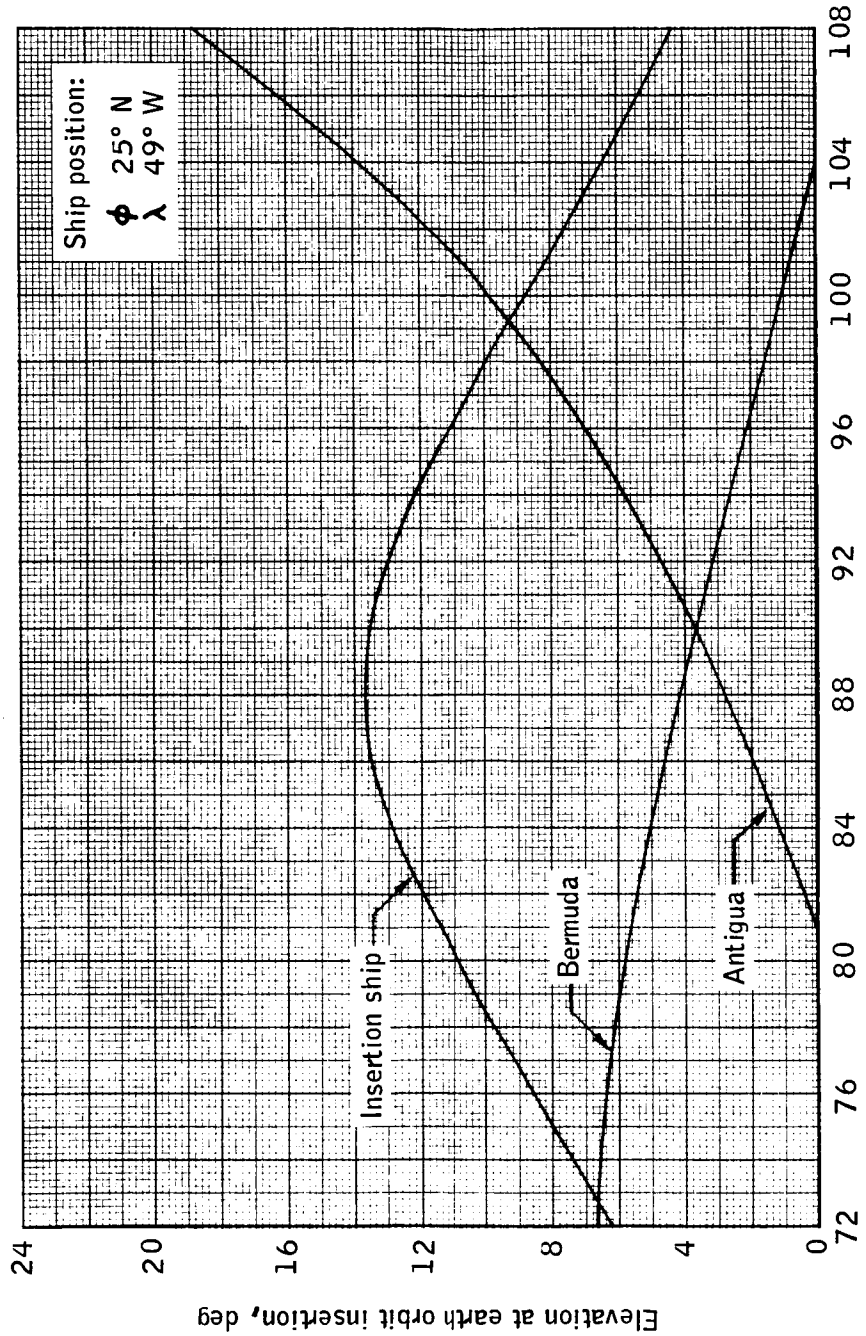
(a) Total tracking time after earth orbit insertion for minimum elevation of 0°.

Figure 21.- Tracking ship locations and tracking coverage.



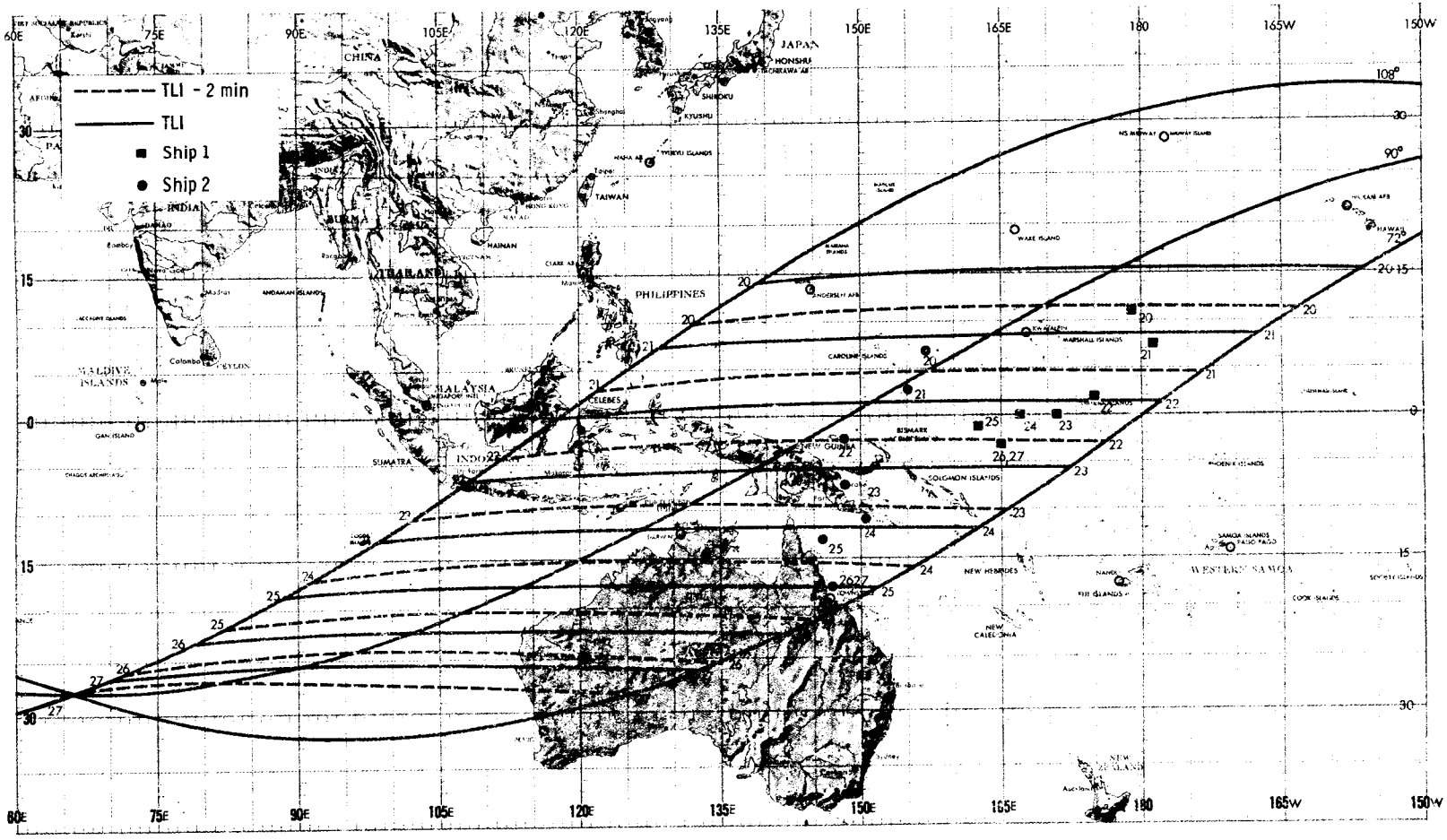
(b) Total tracking time after earth orbit insertion for minimum elevation of 5°.

Figure 21.- Continued.



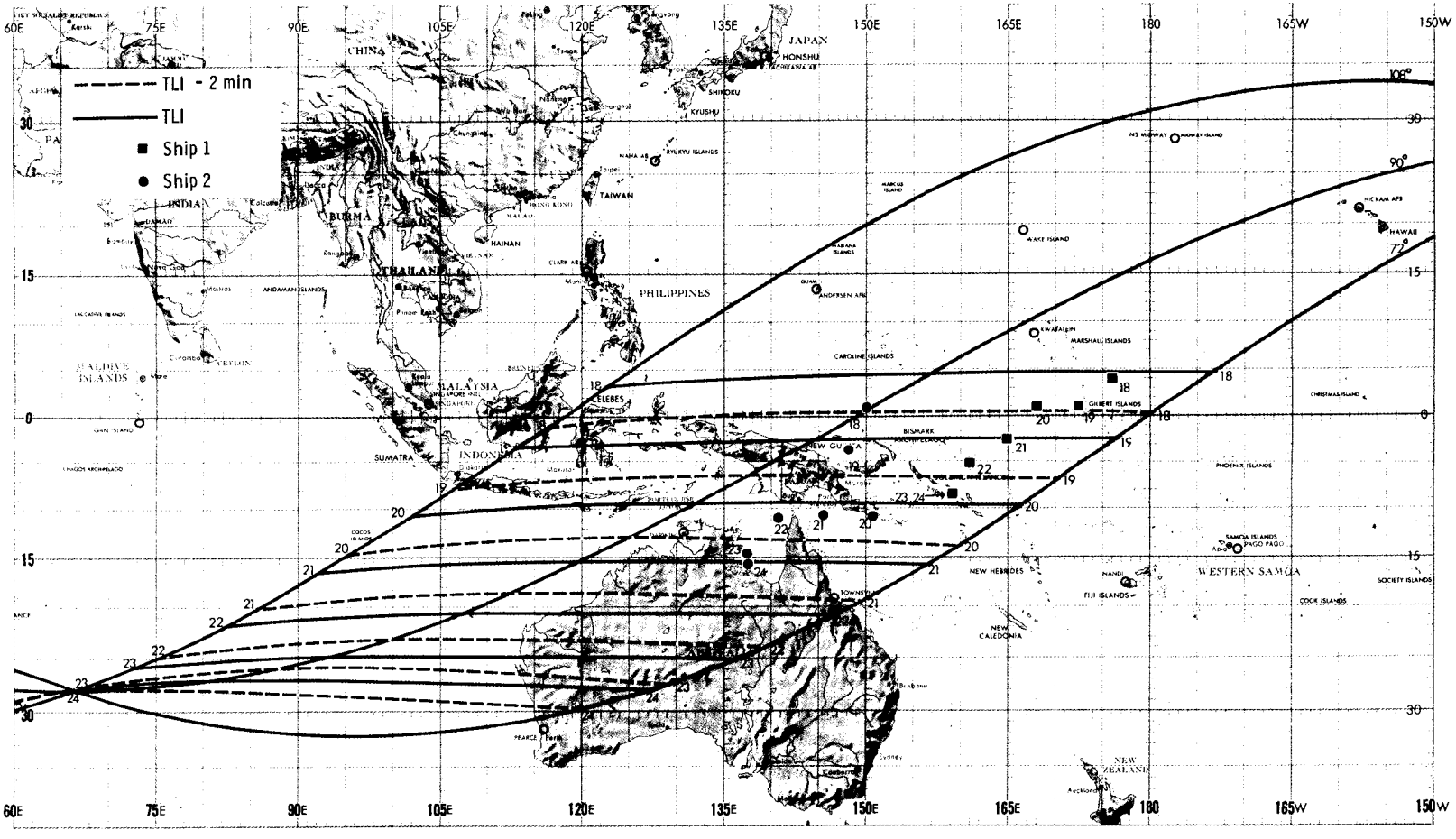
(c) Elevation at earth orbit insertion versus launch azimuth.

Figure 21.- Continued.



(d) Translunar injection tracking ship locations for the December 1968 launch window.

Figure 21.- Continued.



(e) Translunar injection tracking ship locations for the January 1969 launch window.

Figure 21.- Concluded.

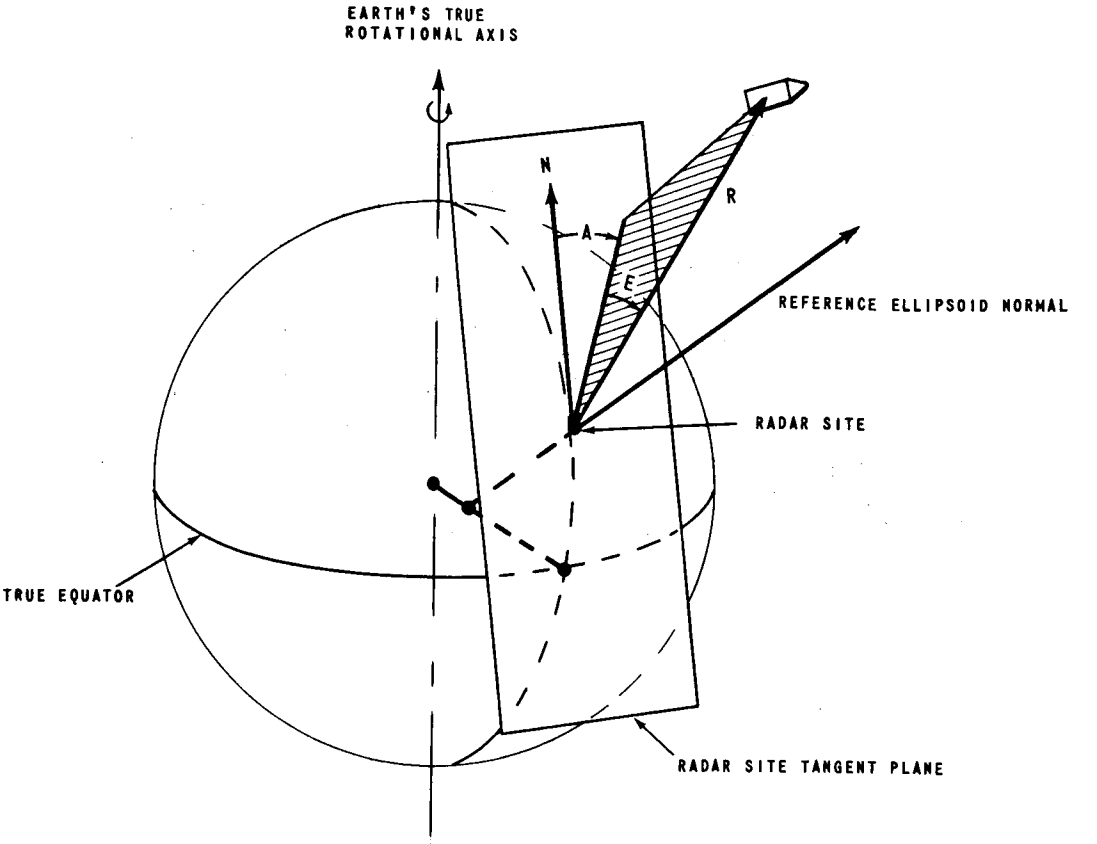
APPENDIX

STANDARD RADAR COORDINATE SYSTEM[a]

[a]The coordinate systems definitions were taken from "Project Apollo Coordinate System Standards" reference (16).

STANDARD COORDINATE SYSTEM 3a

RADAR (AZ-EL)



TYPE: Rotating, Earth referenced

ORIGIN: The intersection of the radar axes

ORIENTATION AND LABELING:

The radar site tangent plane contains the site and is perpendicular to the reference ellipsoid normal which passes through the radar site.

R is the slant range to the vehicle.

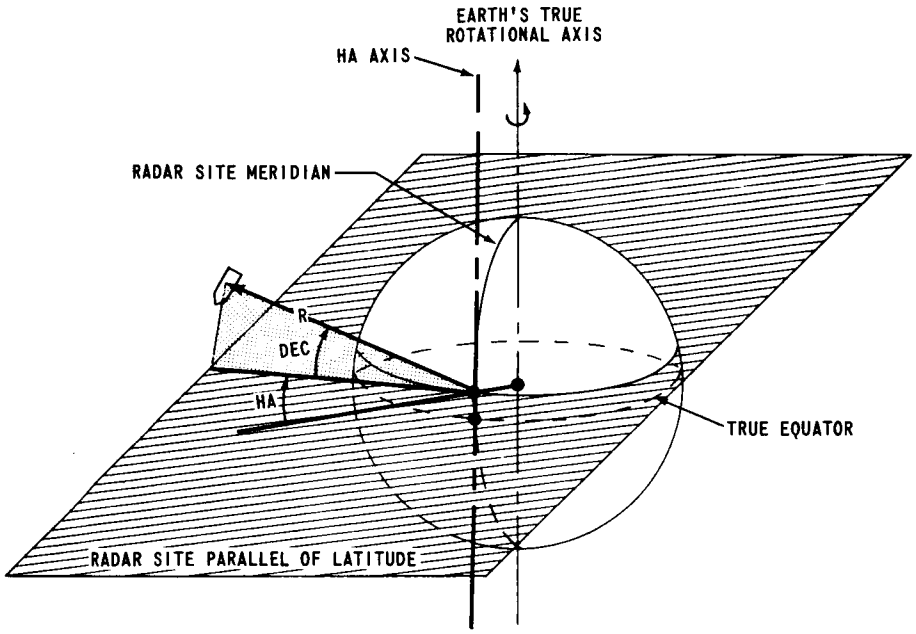
A is the azimuth angle measured clockwise from true north to the projection of the slant range vector onto the radar site tangent plane.

E is the elevation angle measured positive above the radar site tangent plane to the slant range vector.

FIGURE A-3a

STANDARD COORDINATE SYSTEM 3b

RADAR (HA-DEC)



TYPE: Rotating, Earth referenced

ORIGIN: The point of intersection of the hour angle axis with the plane of the declination gear

ORIENTATION AND LABELING:

R is the slant range* to the vehicle.

The HA axis is parallel to the Earth's true rotational axis. The declination axis is parallel to the true equator and perpendicular to the HA axis.

The hour angle (HA) is measured positive westward in the plane of the local radar site parallel of latitude, from the radar site meridian plane to the plane perpendicular to the equator and containing the vehicle and the radar site.

The declination (DEC) is the angle measured from the radar site parallel of latitude to the vehicle, positive north and negative south of this plane.

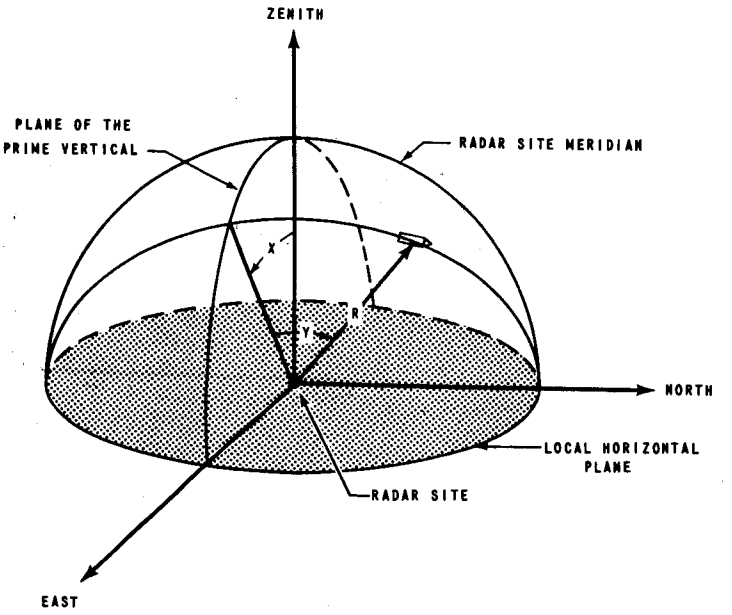
---

* Range rate ($\dot{R}$) data is also generally available in this system.

FIGURE A-3b

STANDARD COORDINATE SYSTEM 3c

RADAR (X-Y 30 ft.)



TYPE: Rotating, Earth referenced

ORIGIN: At the intersection of the X axis and the plane of the Y axis gear

ORIENTATION AND LABELING:

R is the slant range* from the radar site to the vehicle.

The X axis lies along the intersection of the horizontal plane and the meridian plane at the radar site. The Y axis is perpendicular to the X axis.

X is the angle measured in the plane of the radar site prime vertical from the zenith to the projection of the slant range vector onto this plane, positive eastward.

Y is the angle between the slant range vector and its projection onto the plane of the radar site prime vertical, positive when the slant range vector is north of the plane and negative when it is south of it.

(When the radar antenna is directed toward the zenith, the X and Y angles are zero and the Y axis is perpendicular to the radar site meridian plane.)

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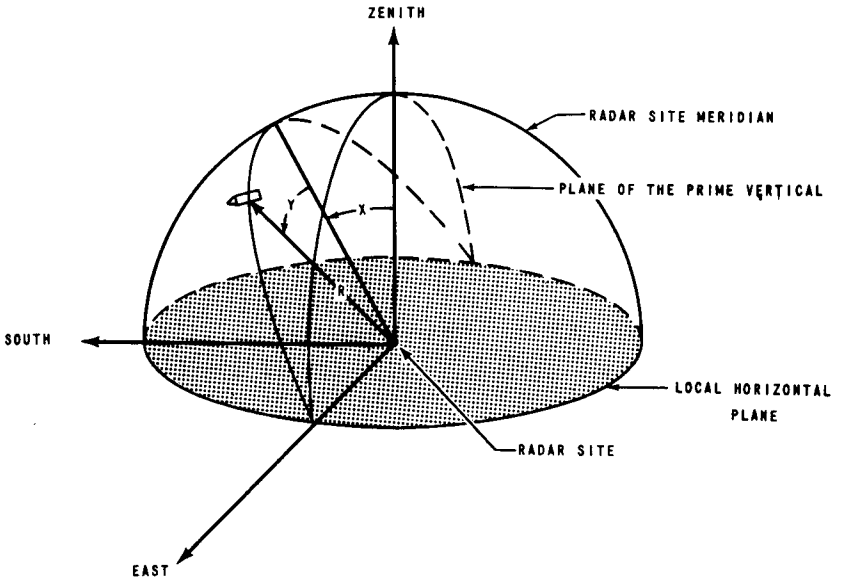
*Range rate ($\dot{R}$) data is also generally available in this system.

FIGURE A-3c

STANDARD COORDINATE SYSTEM 3d

RADAR (X-Y 85 ft.)



TYPE: Rotating, Earth referenced

ORIGIN: At the intersection of the X axis and the plane of the Y axis gear

ORIENTATION AND LABELING:

R is the slant range* from the radar site to the vehicle.

The X axis lies along the intersection of the horizontal plane and the plane of the prime vertical at the radar site. The Y axis is perpendicular to the X axis.

X is the angle measure in the meridian plane of the radar site from the zenith to the projection of the slant range vector onto this plane, positive southward.

Y is the angle between the slant range vector and its projection onto the meridian plane of the radar site, positive when the slant range vector is east of the meridian plane and negative when it is west of it.

(When the radar antenna is directed toward the zenith, the X and Y angles are zero and the Y axis is perpendicular to the radar site prime vertical plane.)

---

* Range rate ($\dot{R}$) data is also generally available in this system.

FIGURE A-3d

REFERENCES

1. Jiongo, Edward M.: Revision 1 to Lighting Geometry for the Apollo C' Alternate 1 Mission. MSC IN 68-FM-266, October 28, 1968.

2. Marshall Space Flight Center: Operational Trajectory Data Report; AS-503 C' Launch Vehicle Operational Trajectory for December 1968 Launch Window. October 22, 1968.

3. Collins, Michael A., Jr.: "C-prime" Data. MSC memorandum 68-FM13-497, August 28, 1968.

4. Jiongo, Edward M.: Trajectory Parameters for AS-504-type Missions, Volume I - Earth Parking Orbit Phase. MSC IN 67-FM-101, July 24, 1967.

5. Mission Design Section, TRW Systems Group: Lunar Mission Earth Parking Orbit Communications Analysis. TRW note no. 68-FMT-627, April 1, 1968.

6. Jiongo, Edward M.: Preflight Tracking Data for the Launch Phase of a Lunar Mission. MSC IN 68-FM-38, February 14, 1968.

7. C-prime Simulator Data Package. MSC memorandum 68-FM13-558, September 23, 1968.

8. CSM/LM Spacecraft Operational Data Book, Volume III - Mass Properties. SNA-8-D-027, March 1968.

9. CSM/LM Spacecraft Operational Data Book, Volume I - CSM Data Book. SNA-8-D-027, May 1968.

10. United States Weather Bureau: U. S. Standard Atmosphere, 1962. December 1962.

11. MIT: Guidance System Operations Plan for Manned CM Earth Orbital and Lunar Missions Using Program COLOSSUS, Section 5, Guidance Equations, Revision 2 - R577. July 1968.

12. Tolin, J. W., Jr.: RTCC Requirements for Missions D, E, and F: Reentry Phase. MSC IN 68-FM-216, August 30, 1968

13. Ried, Robert C., Jr.: Apollo Command Module Enter Air Radiation Heating Rate. MSC memorandum ES5/1-2/67, January 9, 1968.

14. Heating Rate Factors for Reentry Studies. MSC memorandum ES5/9-11/173M, September 14, 1967.

15. Plasma Effects of Apollo Reentry Communication. NASA/GSFC X-513-64-8, January 1964.

16. Office of Manned Spaceflight: Project Apollo Coordinate System Standards. Office of Manned Spaceflight document SE-008-001-1, June 1965.